

ON THE TERTIARY FLORA OF THE NORTH AMERICAN LIGNITIC CONSIDERED AS EVIDENCE OF THE AGE OF THE FORMATION

The purpose of this memoir, as indicated by the heading title present, with more details, the evidence offered by the flora of the Lignitic Measures of the West, in regard to the geological age of the formation, which I consider as Tertiary. The reasons advanced in favor of this opinion in the two former annual reports of Dr. Hayden, and a paper in the American Journal of Science and Arts,* are controverted by some geologists who consider the Lignitic as Cretaceous, denying to the Lignitic paleontology the authority of evidence in a question of this kind. Their arguments may be briefly exposed in the order in which I propose to examine and discuss their importance.

1st. Fossil plants are rarely found in the geological formations of the West; they are mostly marine; the vegetable remains are generally undetermined fragments of leaves; they have been, as yet, scarcely studied in the country; the records of the fossil floras are nearly mere blanks.

2d. If even the fossil flora of the great Lignitic of the West had been widely studied, it could not afford any reliable evidence, on account of the impossibility of a conclusive comparison of its species. A comparison of the fossil plants of this continent with those of Europe cannot be made in regard to identification of geological periods, for the reason that at the same epoch the floras of both continents may have been very different in their character, a necessary result of differences in atmospheric circumstances of the same period of time.

3d. Even supposing that the evidence could be admitted, it is nullified by the presence of cretaceous animal remains in strata well above the lignitic formations, and animal remains must have been used for the determination of geological groups.

4th. The strata of the Lignitic conformably overlies the Cretaceous; the nature of the compounds of these so-called different formations is very similar.

5th. Stratigraphy and animal paleontology have forced the conclusion in regard to the cretaceous age of the western Lignitic, and geologists of high standing have, by their opinion, given full authority to this conclusion.

The text of the argumentation in favor of the cretaceous age of the Lignitic is here exposed in the fairest possible way. It could not be merely that the objections have been already considered and answered, but nobody would be satisfied or enlightened by this assertion. It is therefore, advisable to reconsider the subject and to expose, instead of contradicting arguments, facts, which, corroborating former assertions, bring some new light upon the controverted question. For, in 1

*Annual Report of the United States Geological and Geographical Survey, &c. for the years 1872, p. 318, &c. Same Report for explorations of 1873, p. 367. The age of the lignitic formations of the Rocky Mountains, American Journal of Science and Arts, vol. vii, June, 1874.

past years, the researches in the vegetable paleontology of the Silurian have greatly added to what was known of its domain when the former reports were published.

To consider the first objection—that fossil plants are rarely found in geological formations which are mostly marine; that the vegetable remains are mostly undeterminable fragments of leaves; that they have been scarcely studied; and that the records of the fossil flora are meagre—it will be necessary to open a while these so-called blank records of the North American geological floras and look over them a little.

We cannot boast, indeed, of a wide acquaintance with the fossil flora of the Silurian, for the good reason that they have been rarely collected and studied. The formations of that epoch being mostly marine, the flora is represented by faucoidal remains, or plants which, owing to a soft texture, have generally been deformed and rendered undeterminable by maceration and compression. Prof. James Hall has, however, described some of those primitive vegetable forms, and his contributions to the vegetable paleontology of the Silurian have been acknowledged and honorably recorded by European authors. Of the fossil species of silurian plants described by Göppert in his *Flora of the Silurian of Transition*, sixteen are credited to the authorship of Hall.

Besides the general instruction afforded by the representation of these plants of primitive ages, we find in them already, though not in their characters may be, an authority for the identification of similar strata in far distant countries. It is the case, for example, with *Stenoma fimbriiforme*, Hall, Rich., which identifies, by its abundance, the Lower Silurian of Norway and of Bohemia, &c., the Lower Silurian of England, Ireland, and the strata of the same age, the Potsdam group of the United States and Canada.

As I have merely to consider the remains of land-plants, the Silurian flora might be left out of notice as foreign to the subject. But even land-plants have their history, at least the first lines of it, written in these silurian formations, considered till now as a succession of marine deposits, as a time when our planet was surrounded by water, and when as yet there was no land exposed to view. Two years ago a group of the Silurian, near Lebanon, Ohio. They were, after examination, considered as remains of land-plants, and as representing upon their surface the impression of scars as a species of *Sigillaria*. This opinion, which was then contradicted, is now fully confirmed by a new and more careful examination, made by competent judges, who admit that the remains in question can represent only land-plants. We would, therefore, chronicle the presence of land covered with vegetation at the dawn of the Middle Silurian, if we had positive evidence concerning the origin of these remains in the locality indicated by their labels. It is, indeed, supposable that those fragments may have been found elsewhere also, and have been casually mixed with specimens of the Silurian group, though the place of origin is positively known and vouched for by the owner of the specimens. The presence of land-plants in the lower Silurian receives, however, a degree of probability from the recent discovery of remains of two species of this kind in the Lower Helderberg of Michigan. Here no doubt is left either in regard to the character of the plants, which are clearly exposed, or to the locality and its reference to the formation.* One of the species is a small *Psilophyton*; the other belongs to the genus *Aspidaria*, but is evidently

* This discovery is due to Dr. Roominger, State geologist of Michigan.

new, and of peculiar characters. Both were growing together, apparently in the place where they have been found, as they are inhabited by a small fluvial or land shell, a serpulid, very much like the *Spirorbis* so commonly observed upon coal-plants of the Carboniferous. This shell is still smaller, and without the transverse striae observable upon the species of the Coal-Measures.

The conclusion in regard to the presence of land-vegetation in the Silurian had been already recorded by Professor Dawson, but less positively ascertained, however.* He remarks that in the marine limestone of Cape Gaspé, holding shells and corals of Lower Helderberg age, they have fragmental stems and distinct rhizomes of *Psilophyton*, adding that these fragments must have been drifted from the land. In the present case, or with the vegetable remains of Michigan, the fragments are so delicate, their minute divisions so well preserved, that evidently their habitat was in close proximity to the place where they have been found, or rather that they lived in shallow basins of water bordering the shores, this being especially indicated, as remarked above, by numerous small fluvial mollusks, either placed upon the plants, or scattered around upon the stone.

Remains of this kind, evidence of open land in the Upper Silurian age, may be hereafter more frequently recorded and found also still lower in this formation when more care is given by geologists to the collection and examination of fossil plants. Though it may be of the future, these fragments of old lycopodiaceous species in the Silurian appear there as the ancestors of a long and multiple series of analogous forms, all remarkably well characterized, and which, from the Lower Devonian, increase in a remarkable proportion to the base of the Carboniferous, where their remains enter for a large proportion into the composition of the coal.

The list of the Lower Devonian plants is not as yet very long. But it is a matter of course, for the strata of this formation, at least in the United States, are mostly marine, and the fossil vegetable remains in connection with them represent marine plants which have been till now scarcely studied in this country. That they are very abundant, is proven by the fact that they have become by their presence noticeable characters of whole geological epochs to which they have given their name, as for example, *Fucoides Cauda-Galli*, for the Cauda-galli grit, the lower member of the Corniferous period.

Marine plants, though admirably beautiful they may be, some of them at least in their living state, have nothing attractive as fossils. Their fronds and branches are generally flattened by compression, and in that way, too often disfigured and generally mixed into an amorphous mass, where the eyes rarely discern any trace of organization or of configuration acceptable as reliable characters. The paleontologist, therefore, needs for the study of these plants the greatest care and a large number of specimens, which are rarely obtainable; for the plants and their ramifications either cover wide surfaces of hard rock, or penetrate it in various directions. I believe, however, that with time and perseverant researches, paleontologists will be able to determine a number of those obscure remains, and point out by their presence the distribution of some separate groups of the Devonian. But this subject is out of the present discussion.

There is in Canada a great sandstone formation known as the Gaspé, over seven thousand feet thick, which has few animal remains in its

* Fossil Plants of the Devonian and Silurian Formation of Canada, pamphlet (1871), p. 78.

conformable, and whose geological relation has never been satisfactorily ascertained either by stratigraphy or by animal paleontology. Professor Dawson refers its lower part to the Oriskany sandstone of New York, but offers no positive evidence, however; its middle part is doubtfully considered by Professor James Hall as representing the Hamilton group. Taking into consideration the data supplied by fossil plants whose remains have been found from the base to the top of this formation, Professor Dawson finds that they represent a succession, by multiplication of specific or generic forms, of the whole Devonian flora, as far as it is known at present, and that therefore this enormous accumulation of sandstone has been in constant process of formation during a whole epoch, extending in its successive strata the gradual development of its vegetable types. These divisions are not as yet positively defined by the observations of Montreal. But surely a more detailed study of the distribution of the species of fossil plants of the Gaspé will enable the paleontologist to fix, by the grouping of related forms of plants, the different stages of the Devonian land formation, and thus afford points of comparison for future researches.

This we can do distinctly for the Carboniferous age, taking as its beginning or its base the Old Red Sandstone, represented in this country by the Catskill period. In the Upper Chemung, we have here, as in Canada and in England, some few remains first representatives of a peculiar group of ferns, whose characters have no relation to those of any species of our time. Its species have been described by the authors under various generic names. They are referred to *Oxylopteris* or *Adiantum* by some; to *Noeggerathia* or *Sphenopteris* by others; to *Arochopteris* or *Paleopteris* in more recent works. This multiplication of generic names does not refer to uncertainty of characters. Every paleontologist knows these plants; but their undefined analogy has forced different points of view in regard to their relation, and therefore caused this confused terminology. These ferns, from their rare presence in the Devonian, become so predominant in the red shale of the Catskill period in this country, and of the Old Red Sandstone of Europe, that they are acknowledged even by geologists who do not take any account of vegetable paleontology. The more common species of this group of ferns—*Paleopteris hydnoides*, *P. Roemerii*, *P. Boschi*, described first from the Red Sandstone of England, are represented in the red shale, No. 12 and 13 of the Pennsylvania geological reports, (the Catskill,) below Portage, Mauch Chunk, and other places. *Paleopteris Halliana* and *P. Jacksoni* are American species of the same type. In Europe two species, *P. Roemerii* and *P. unguiculata*, ascend to the Sub-Carboniferous limestone, and here also, as will be remarked below, we have two species known already in the next higher stage of the Carboniferous. Therefore the predominance in the Catskill beds of a group of plants which is still represented by a number of species at a higher stage of the Carboniferous, marks its place with the last geological division rather than with the Devonian. These *Paleopteris* species, like those of *Megalopteris* mentioned in the following division, have often been considered as Devonian types; this, apparently, because the Old Red Sandstone has been often and is still sometimes admitted as Devonian. All the European species described are referred to the Old Red or to the Culm, or Sub-Carboniferous; those of Canada to the upper beds of Gaspé, a formation which, as remarked already, is not yet limited in its divisions, and may represent the Catskill by its upper members.

To this lower member of the Carboniferous are referable a number of

species of plants described by Prof. B. F. Meek, in proceedings of the Washington Philosophical Society (1872). The specimens, which represent three very fine species of *Paleopteris*, a *Lepidodendron*, a *Sigmaria*, and a *Carpolithes*, were obtained from Lewis's tunnel, Alleghany County, Virginia, in the lower part of the Sub-Carboniferous measures, near its junction with the Upper Devonian.

Until recently there was, between these species of plants of the Catskill and those of the Carboniferous type, a break of relation which could not be accounted for, except by the supposition of a change of formation, as it has been generally done for interruptions of this kind. Therefore, the reference of the Catskill beds to the Devonian was indubitable so far; but, two or three years ago, Prof. E. B. Andrews, while connected with the geological survey of Ohio, discovered, in Perry County, in the southern part of this State, a bed of black shale, with abundant, well-preserved remains of ferns of peculiar and remarkable type. These shale, from the remarks of Professor Andrews, are at a distance above the Chester limestone, or on the upper part of the so-called Sub-Carboniferous measures of the West. Somewhat later, Mr. L. H. Southwell, of Port Byron, Illinois, sent from that locality, as discovered, also, in a bed of soft black shale, underlying the true Carboniferous measures, a number of specimens representing some of the most predominant forms observed in the shale of Perry County. This peculiar group of plants has still two species of *Paleopteris*, one of them closely allied to *P. Jacksoni*, the other, like *P. obtusa*, figured in Dana's Manual of Geology, with some of the pinnules deeply emarginate at the top, or bilobed. The majority of its species, however, are referred to *Megalopteris*, a new genus established by Dawson, and represented by ferns with immense fronds, large decurring leaflets, often divided in the middle, in two lobes, by the forking of the middle nerve. One species, about the same character, is described by Professor Andrews under the generic name of *Orthogoniopteris*. The specimens from Port Byron, Illinois, represent, also, more generally, species of *Megalopteris*, one of them especially remarkable by the agglomeration or tufting of the terminal leaflets, which divide, above the base, in two, more rarely three, equal lobes, by the forking of the middle nerve, as remarked above. This mode of division of the leaflets is exceptional in ferns of this kind, and has never been observed except in one species of the lowest coal bed of Illinois, the first above the millstone grit, and described in the 4th volume of the Geological Reports of that State as *Neuropteris fasciculata*.

Professor Schimper, in his Vegetable Paleontology, mentions this species as a very singular one; and the discovery, in a lower member of the Carboniferous, of species to which this peculiar conformation is traceable, affords a point of comparison which cannot be overlooked in searching either for geological relation or for an affinity of vegetable type. Allied to the plants of the Catskill group by its *Paleopteris*, to the so-called Upper Devonian of Canada by the *Megalopteris*, the flora of Port Byron passes to that of the subconglomerate Carboniferous of Arkansas by a small *Arterophyllites*, *A. gracilis*, which is present, also, in the shales of Perry County, and described, too, in the Pre-Carboniferous flora of Canada as *A. parvula*; by *Lepidodendron modulatum* and *L. carolinianum*, two species found also in Arkansas in subconglomerate coal beds; by *Cardiocarpon Southwellii*, similar to *C. ingens*, of Arkansas; and it has, also, one species, *Sagenaria depressa*, Göpp., of the Culm or Sub-Carboniferous of Europe, and another intimately allied to

Sphenopteris crassa, described by the same author from the same formation, the *Poissionien schieffer*. The examination of a large collection of specimens from the coal-measures of Alabama affords the means of extending the comparison of these floras somewhat further, for, till now, the subconglomerate coal flora was merely known by the species described from Arkansas.* That of Alabama is composed of a large number of species as yet unobserved in this country; some of them, however, described by European authors, by Brongniart, Lindley, and Hutton, especially, from the lowest coal-beds of England and of France, inferior in station to the millstone grit.

There is, for example, *Sphenopteris Hoeninghausii*, predominant in the same number of specimens; three species of *Eremopteris* a common element; *Neuropteris*, recalling the type of *Paleopteris* of the Old Red sandstone; *Lepidodendron*, some identical with species of the measures above the conglomerate; some of a peculiar type, one especially, with branches covered both by leaves and scales, and *Ulodendron minus*, of the Lower Carboniferous of England. Hence we have in the subconglomerate coal of Arkansas and of Alabama another intermediate flora uniting types of the coal above the millstone grit with those of the Perry shales, as these served as point of transition between the Catskill flora and that of the subconglomerate coal. It is thus to this point an uninterrupted series of vegetable forms.†

The characters of the floras of both stages of the Carboniferous overlying the conglomerate are well known. The lower, in connection with beds of coal of remarkable thickness, especially in the anthracite fields of Pennsylvania, has a profusion of Lycopodiaceae. There abound species of *Lepidodendron*, *Ulodendron*, *Knooria*, genera represented mostly by very large trees; some ribbed *Stigmaria*; large-leaved species of *Alathopteris*, of a type probably derived of the *Megalopteris* of old, like *A. Serlii*, *A. Sullivanii*, *A. pennsylvanica*, *A. lonchitico*, with its numerous varieties, *A. nervosa*, which, like the former, appears already in numerous specimens in the flora of the Alabama coal; *Sphenopteris*, species related by their character to those of Arkansas, like *S. Gravenhorstii*, *S. longipes*; numerous species of *Hymenophyllites*, and hard fruits, *Cordaites*, *Cardiocarpi*, and *Trigonocarpi*. All this gives to the supra-conglomerate coal a character which is especially predominant in the lowest beds. In passing up to the Pittsburgh division, or to the upper coal-measures, the constituents of the flora are gradually modified by the decreasing number of the great lycopodiaceous species, which are rarely found above the Mahoning sandstone of Pennsylvania, and by a proportionate increase of the *Stigmaria* species, especially of the second series. We have in these upper coal-measures, besides these *Stigmaria*, a preponderance of ferns, arborescent species of *Pecopteris*, with large fronds and pinnae are spread upon the shale like small trees, *Pecopteris arborescens*, *P. unita*; some bushy *Neuropteridea*; *Neuropteris*, especially the most common of all; a profusion of *Calamites*, *Cordaites*, and still one species of *Alathopteris*, *A. aquilina*, a diminutive form. Whenever remains of fossil plants are found in connection with a coal, paleontology easily recognizes their relation to the upper or the lower division of the supra-conglomerate Carboniferous measures. From this it follows that from the base of the Catskill group to that

the Permian, vegetable paleontology is able to discern and expose the characters of five divisions of the Carboniferous, each determined by peculiar species of plants, and each also related by analogous or even identical species to both the preceding and the following stages of the formation.

The records of the paleontology of the Coal-Measures are not less positively referable and less interesting to geology when they bear upon questions of a wider and more general application. To my knowledge no fossil plants from the Coal-Measures of North America were described before 1818; in that year Rev. Steinhauer published in the Transactions of the American Philosophical Society* his *Fossil reliquia*, where, he describes and figures, under the generic name of *Phytolithus*, a few species of *Calamites*, *Lepidodendron*, *Ulodendron*, *Artisia*, *Stigmara*, and *Stigmara*. He mentions, however, in the introduction, that most of the specimens of fossil plants from the Carboniferous represent *Filices* (ferns). After him Granger, in 1820, merely mentions a few specimens of coal plants from Zanesville, and refers them to Steinhauer, species.† From that time to 1828, Granger, Oist, and Professor Silliman sent some specimens of fossil plants from the Coal Measures of Pennsylvania and Ohio, to Brongniart, who was then preparing the materials for his great coal flora. They represented, as seen from this work, ten species, three of which only were then peculiar to this continent. In 1837, Dr. Hildebreth, of Marietta, so well known by his love and zeal for the study of natural history, and its original researches in some of its branches, described in the journal of his geological explorations‡ a number of species whose figures are mostly unrecognizable, and whose references are equally uncertain. The remarks of the author, however, denote long and serious researches into the distribution of the coal-beds and the fossil plants recognized in their connection. For ten years after this nothing is said upon our Carboniferous flora until 1847, when Teschermacher prepared, on the fossil vegetation of North America, a very interesting and valuable, though too short memoir, published in the Boston Journal of Natural History.§ At that time the great paleontological works of Brongniart, Sternberg, Göppert, and Unger were already published, and therefore the author was able to more clearly analyze and describe the specimens which, then, very rare, as he says, were obtained from New Scotia, Rhode Island, and Mansfield, Mass. He is the first to remark upon the affinity of the Carboniferous flora of America to that of Europe, thus opening the way for a greatly-needed comparison between the coal floras of both continents, to which some questions of high interest to geology were then and are still related. Teschermacher mentions in his pamphlet twenty-three species, some of them described and obscurely figured also, all more or less positively referred to species known from European authors except one. This, he says, has no relation to any known by him. It is left without description and without name. The figure represents a fragmentary specimen of the most beautiful fern of the Coal-Measures, *Odontopteris Agassizii*, which has never been found but in Rhode Island, and of which splendid specimens are preserved in the Agassiz museum of Cambridge.

In 1850, Prof. H. D. Rogers, then director of the geological survey of Pennsylvania, requested the assistance of a paleontologist for the collection and the study of the fossil plants of the anthracite basin.

* Geological Report of Arkansas, vol. II, pp. 295-319.

† Prof. E. T. Cox, State geologist of Illinois, has quite recently sent me for determination a box of specimens from the whetstone grit, 25 feet lower than the base of the conglomerate. They represent species either identical with or intimately allied to those of the flora of the subconglomerate coal of Alabama.

* Vol. I, new series, p. 265.

† Silliman's American Jour. Sci., vol. III.

‡ Ibid., January, 1836, and January, 1837, vols. XXIX and XXXI.

§ Vol. v, part 3, June, 1847.

The work was systematically begun and pursued, first, by the collection and the examination of specimens of fossil plants in the different basins of the anthracite, where, in some cases, coal-beds, exposed in the same position and therefore disconnected, were identified by their vegetable remains only. The researches were then extended for comparison in different parts of the so-called Appalachian or bituminous coal-beds of Pennsylvania, in order to ascertain if both basins, that of the anthracite and that of the bituminous coal, were positively of the same formation, and if the distribution of the fossil plants could indicate not only identity of period, but conformity in the deposits of the coal-beds. These questions have been examined and answered in the Introduction to the fossil flora of the coal-measures in the final Report of the Geological State Survey of Pennsylvania, and the data which were the basis of these researches have been accepted as reliable and remain ever since. This is followed in the same introduction by the comparison of the Carboniferous flora of Europe with that of North America, in so far as this flora was then known, by more than one hundred species described and figured in the Pennsylvania geological report, and by as many more published in a catalogue of the fossil plants of the Coal-Measures, by the Pottsville Scientific Association in 1858, and repeated in Professor Rogers's report. The intimate relation of the coal flora of the two continents is there discussed and forcibly established by the identity of types, even specific identity for the greater number of coal-plants.

Later, vegetable paleontology was called to supply some evidence in regard to the kind and degree of relation existing between the distribution of the measures of the so-called Appalachian coal-basin with those of the Indiana and Illinois coal-fields, to which belongs the western coal-basin of Kentucky. Researches of the same kind were pursued by the exploration of coal-beds and the determination of the specimens of fossil plants found in connection with them. The results of this study have been published long time ago in the geological reports of Kentucky, under the direction of Dr. Dale Owen, and in those of Illinois, under that of Dr. H. Worthen. They have exposed, not merely a general identity of the coal-plants of the western basins to those of the east, but, in most cases, an identity of species, varied only by the presence of a number of rare, peculiar forms, remarked once only at a sole locality or kept again here and there, even at far distant points. This fact, in accordance to the laws of geographical distribution, and repeated at the different geological epochs, as well as at this present time. These researches have proved also the intimate relation of the coal-strata, not only to their vertical distribution in both the eastern and western coal-fields, and therefore the synchronism of some of the more important coal-beds over the whole extent of the North American Carboniferous formations. Even then, from the harmony of distribution of the coal-strata on both the eastern sides of the Indiana and Kentucky basin and the western side of the Ohio Coal-Measures, as also from the identity of the characters of their constituent plants, it had been inferred that the upheaval of the Silurian ridge which separates them has succeeded the formation of the coal, and that therefore these now separated coal-fields have been originally united. This opinion has been contested on the observations derived from stratigraphical evidence. I think, however, that new discoveries, like that of strata of exactly the same composition with plants of identical species, as the Sub-Carboniferous fossil-beds of Perry County, Ohio, and of Port Byron, Illinois, will corroborate the conclusions dictated by vegetable paleontology. Anyhow,

these researches have demonstrated the possible identification of the coal-strata, a fact whose application, however, can become valuable to coal-mining when we have more positive knowledge on the geographical and stratigraphical distribution of the plants of the American Coal-Measures.

In the Permian, as far as at least as this formation is known by the exposure of its rocks in Iowa, Nebraska, and Kansas, near the junction of the Platte with the Missouri River, the records of vegetable paleontology are blank indeed; for the sufficient reason that this formation is represented there only by magnesian limestone or marine rocks whose only fossil remains are invertebrate animals, the so-called Permo-Carboniferous species, most of them indifferently referable to Carboniferous or to Permian. But sandstone rocks have been observed in the Rocky Mountains, which, without any animal remains, have been, from the nature of their composition and from their superposition to old Paleozoic strata, considered as referable either to the Carboniferous or to the Permian. A few fragments of Calamites only, found in connection with this formation and sent for determination, were sufficient to establish its relation to the Permian, for the Calamites represented by these specimens, *C. gigas*, is a leading plant of the Lower Permian. This case has recently repeated from a locality far distant from the former, and the same reference equally established from a few specimens only. It cannot be said in this case, as for the Carboniferous, that the general characters of the plants are well known, and that therefore vegetable remains of this formation may be used sometimes for determination, when topography and animal paleontology cannot be taken as guides; for, to my knowledge, the above-mentioned specimens are the first vegetable remains discovered as yet from American Permian rocks.

For the Trias, the evidence supplied by vegetable paleontology is presented in opposition to that derived from animal remains, by one of the highest geological authorities of this country. This formation, exposed in North Carolina, and in Virginia near Richmond, also, has important deposits of coal, whose age has been for a long time in discussion among geologists; and has been definitively fixed by the remains of fossil plants found in connection with them. In the last work published by Emmons, American Geology, Part VI, the lower part of the section of page 17, headed Permian, is described as the Chatam series, and its fossils, a few fossil remains of uncertain affinity and a large number of animal remains, crustacean, mollusks, fishes, saurians, are not considered as sufficient to authorize a decision upon the age of the formation, which is therefore left as uncertain. The upper part of the measure, however, has in its divisions layers of shales, with plants, and though remains of animals are not found in connection with this series, it is positively determined as Triassic by the author, from vegetable paleontological evidence only. The characters of the plants, as indicated especially by the *Oxycetes*, relate this flora to the Jurassic of Europe; hence its appellation of Triasso-Jurassic, given to the formation. I say the Jurassic of Europe, for indeed this formation is as yet so indefinite in this country that it has no records of any kind which may be used as points of comparison. Its flora is totally unknown; and even if we had a few vegetable remains obtained from the strata considered as Jurassic in the Black Hills, the Uinta Mountains and the Sierra Nevada, it is very questionable if they could be used for identification of the formation. The Jurassic, even for Europe, is the dark age of vegetable paleontology. Except the oolitic coal deposits of England, its strata of enormous thickness

In some regions are mostly marine, and have as yet afforded too scanty materials to define somewhat clearly the characters of its flora in the numerous subdivisions of the formation.

The Cretaceous flora of North America, as far as it is known from its representatives in Kansas, Nebraska, Dakota, and Minnesota, has been reviewed in this report and speaks for itself. Its characters, as they are known now, will be more expressively compared to those of the Lignitic flora, and the differences more distinctly seen when the Tertiary species are published with figures. From the multiplicity of its types, some of them transient or indefinite, it is now easily understood that the attempt of a comparison of the few first leaves discovered in Nebraska could but mislead the most competent and careful paleontologist in looking for typical relation in order to determine their age. The record of this Cretaceous flora could not be read, indeed, before they had been written, or when they were exposed by a few scattered words only. Even the North American Cretaceous plants represent a definite group, which, though susceptible of wide extension by new discoveries, has its essential characters already defined, and is thus available as a point of comparison for paleontological documents, either from this country or from Europe. It is in this point of view especially that the importance of the publication of the fossil plants of this country has to be judged. That the geological age of the Dakota group flora, as long as its characters were unknown, should have been subjective to the evidence afforded by its overlying marine strata, which were clearly determined by invertebrate animal remains, is a matter of course. But now this flora affords a collateral evidence which by its vegetable types may be used for geological determinations just as legitimately as the fauna. From a subordinate it becomes an assistant.

I consider that this discussion upon the authority of vegetable paleontology in regard to the determination of the age of the disputed strata, Cretaceous Lignitic or Lignitic Tertiary, has been of great value to American geological science. It has induced wide and more careful researches, and brought forth a large number of important discoveries which, without it, would have probably been indefinitely postponed. No department of geology should be disregarded or considered as of an inferior concern. All have an equal right as members of a same body. And was it only for the reason that vegetable paleontology has been generally, and is still now, considered by many as of little value as an assistant to geological pursuits, I am the more disposed to persist in putting it forward as an authority superior to that of animal paleontology for the determination of the age of the strata of land formations.

The above remarks all tend to the same purpose, and serve as an introduction to a more detailed examination of the age of the Lignitic as exposed by the fossil flora.

To appropriately enter into the subject, we should have a clear understanding of the now adopted names and limits of the numerous subdivisions or groups of the Tertiary, as marked by European authors. Though it may be that some of these groups are not positively defined, either in their geological relation or in their paleontological characters, they are serviceable for comparison.

Table of subdivisions of the Tertiary of Europe, according to the flora.

Pliocene. Lower limits not positively fixed; largely developed in Italy.

Miocene.	Oeningen.*
	Mayencian or Helvetian.†
	Aquitanian.‡
Oligocene.	Armissan, Bounieux, and Manosque, France, intermediate between the Lower Miocene and the Oligocene.
	Tongriau.§
Eocene.	Gypses of Aix, Alam Bay, Mount Bolca, London Clay.
	Sheppy, Grès of the Sarthe.
	Upper Landenian: Sézanne same as the Belgian Pannolian.
Pliocene.	Lower Landenian: Sand of Bracheux, Lignitic soissonnaise, (Suessonian.)
	Hersian: Gelinden.
	Limestone of Mons, unconformable to the Cretaceous of Maestrich, which it overlies.

Some authors consider as Cretaceous the sands of Bracheux and Gelinden, as indicated by the characters of the flora of Gelinden.

These subdivisions of the Tertiary of Europe seem to express a proportion of vertical extent in comparison to the American measures of the same age. There may be indeed a marked difference but as yet very little is known of the Tertiary of this continent, and certainly this little is known already, by its wide area and the thickness of some of its divisions, an important place in the North American geology.

Last year Prof. F. V. Hayden discovered, near Point of Rocks, some beds of shale with rich deposits of vegetable remains, and obtained a large number of specimens. This locality is between Black Butte Station, nine miles northwest of it, and Salt Wells, another station of the Union Pacific Railroad, about the same distance farther west. From Prof. B. F. Meek's report and from my own it may be seen that from Black Butte to Point of Rocks, in following the railroad, the northeast-dip of the measures brings successively in view a series of heavy sandstones, interstratified with beds of clay and lignite, whose whole thickness, according to Messrs. Meek and Bannister, is estimated at about 4,000 feet. The series of these rocks is beautifully exposed by a diagram in the report. My own estimation gives only half this thickness. But as I did not take any measurements, the purpose of my explorations

* Represented at Locle, Montaron, Albis, Steckborn, Elgg (Switzerland); Schoenmühl (Austria); Günsburg (Bavaria); Parschlug and Gleichenberg (Syrria); Tokay (Hungary); Salsburgh (Austria); Stradella, Guarone, Sarzanella, Val d'Arno (Italy).

† Represented at Delmont, Deveiller, Aarwang, tunnel of Lausanne, Calvaire, Riant, Mount, St. Gall, Solitude, Mönchen, Ruppen, Alstätt, Oberseger, Buron (as Mayencian); at Pettimont, Estave, Croisettes, Montevallies, Moudon, Payerne (as Helvetian); (Switzerland); Bovey-Tracy (England); Monte Bamboli, Superga (Italy); Menat, Germiny (France); Le Rhône, Wetteren (Lower Lignitic), Basin of Mayence, Kempter, Günsburg (Germany); Billin (Bohemia); Radoboy (Croatia); Tohnsdorf, Köflach, Eibiswald (Syrria); Basin of Vienna (Austria).

‡ Represented at Ralling, Schwartztachtobel, Wäggs, Vevay, Monod, Rivas, Desaley, Rindex, Rochette, Conversion, Brulées, Ruffberg, Rossberg, Höhe-Rhone (Switzerland); Seebach (Alsace); Lower Eocene Tertiary of the Baltic, Spitzberg, Iceland, including, perhaps, the whole miocene series, Greenfield, Mackenzie, Alaska; Cardibone, Salsado, Zorenado Vegrone (Italy); Kumi, Iliodroma (Greece); Menat (France); Rot, near Bonne, on the Rhine.

§ Armissan? Payrac, Saint Jean of Garguer, Basin of Marseilles, St. Rochette (Var.), Gypses of Gargas, Vauluse, Castellane (France); Seebach and Lobau (Alsace); Mount Promine (Dalmatia); Sagor (Krain); Haering (Tirol); Sotska (Syrria); Palenstein and Miesbach (Bavaria); Alsatian and Kuehlin (Bohemia); Sieblo (Rhön Mountains); Bernstätt and Wüstenfeld (Thuringia). — These data on the distribution of the Tertiary in Europe are mostly derived from Schimper's Vegetable Paleontology.

|| Dr. F. V. Hayden's Sixth Annual Report for 1872. Professor Meek's sections and diagram of the measures are given at pp. 530, 539, 534.

in that part of the country being especially the research and the vegetable remains, I readily admit the conclusions of these distinguished geologists who had time to attend to details of stratigraphy. At Point of Rocks Station, where the specimens of Dr. Hayden were found, at a distance of a few miles from the cut-end of the ridge east of the falls, the thickness of the measures is there somewhat less, say, three thousand feet. Though it may be, such a heavy series of strata passed from Black Butte to Point of Rocks that if any part of the so-called Bitter-Creek series is Oretaceous, we may expect to find here fossil plants of this last locality a number of species of Oretaceous type, at least a distinct modification in the characters of the plants. Thirty species represented by the specimens of Point of Rocks are described hereafter, but the deductions derivable from the determination of these plants in regard to evidence of geological age, will be more fully understood by a comparative table exposing affinity or identity of characters with species of other localities. The points of comparison are indicated with the flora of the European and of the Arctic Miocene, of the Canadian Tertiary, of the European Eocene, of Golden, of Black Butte, and of the Oretaceous in general.

Table exposing the relation of the fossil-plants of Point of Rocks.

Species of fossil-plants from Point of Rocks.	Canadian Tertiary.	European Miocene.	Arctic Miocene.	European Eocene.	Golden.	Black Butte.	Oretaceous.
1. <i>Ficus lignitum</i>		An.*	An.				
2. <i>Salvinia attenuata</i>		An.	An.		An.		
3. <i>Salvinella falcata</i>					An.		
4. <i>Salvinella laciniata</i>					An.		
5. <i>Sarracenia brevifolia</i>		Id.	Id.			Id.	
6. <i>Salvinella longifolia</i>						Id.	
7. <i>Salvinella complanata</i>		An.					
8. <i>Salvinella complanata</i>	Id.†						
9. <i>Salvinella complanata</i>	Id.†						
10. <i>Salvinella complanata</i>				An.	Id.	Id.	
11. <i>Salvinella complanata</i>				An.			
12. <i>Salvinella complanata</i>				An.			
13. <i>Salvinella complanata</i>		Id.					
14. <i>Salvinella complanata</i>		Id.		An.			
15. <i>Salvinella complanata</i>		Id.					
16. <i>Salvinella complanata</i>		Id.		An.	Id.	Id.	
17. <i>Salvinella complanata</i>		Id.			Id.	Id.	
18. <i>Salvinella complanata</i>		An.				Id.	
19. <i>Salvinella complanata</i>	An.						
20. <i>Salvinella complanata</i>	An.						
21. <i>Salvinella complanata</i>			Id.			An.	
22. <i>Salvinella complanata</i>			Id.			Id.	
23. <i>Salvinella complanata</i>			An.			Id.	
24. <i>Salvinella complanata</i>			An.			Id.	
25. <i>Salvinella complanata</i>		An.					
26. <i>Salvinella complanata</i>						Id.	
27. <i>Salvinella complanata</i>						Id.	
28. <i>Salvinella complanata</i>						Id.	
29. <i>Salvinella complanata</i>						Id.	
30. <i>Salvinella complanata</i>						Id.	

*An. for analogous; Id. for identical.

Of the thirty species enumerated in this table, one is identical with a Canadian species recognized as Tertiary, as seen below, from the report of Prof. G. M. Dawson's Geological Report. Six are identical with, and six also analogous to those of the Lower European Miocene, two identical with, and one allied to, Arctic Miocene species. Six have close relation to those of the Lower European Eocene, or rather of the

Tertiary division, separated at its base under the name of Paleocene. These are identified and two analogous, in the flora of Golden. Nine identical and one analogous, in that of Black Butte; and four have analogy with Oretaceous forms.

The relation of Point of Rocks with the Canadian Tertiary is especially marked by *Lemna scutata*, a floating plant, described by Prof. J. W. Dawson, in the report of the geology and resources of the region in the vicinity of the forty-ninth parallel. The geologist of the commission, Prof. George Mercer Dawson, obtained the specimens from a bed of clay near the very base of the Lignitic formation, where, according to the information kindly furnished to me, the vegetable remains representing this species were very abundant, but difficult to get from the crumbling shale. Though their reference to any living species is not distinctly marked, the peculiar character of the plants does not permit any doubt about its identity with that of Point of Rocks, which is also represented by numerous specimens. Half the specimens from this place bear remains of this species and of another, *Pistia corrugata*, which may be a new form of the same. In regard to the identity of the Lignitic measures of Canada with those of the United States, the evidence is equally conclusive. The report quoted above proves it, by good sections and diagrams, which indicate the same distribution of Lignitic beds, clay, and sandstone strata, as in the great Lignitic of the Rocky Mountains, of which that of Canada is a mere continuation. It enumerates, also, besides those which are described, a number of plants from the Lower Tertiary, of a higher stage, mostly of Miocene types.

In remarking upon the fossil plants which he had to determine, the celebrated professor of Montreal, J. W. Dawson, says, "That the plants of the first group are for the most part identical with those found by American geologists, in the Fort Union series, and which have been determined by Professor Newberry and by M. Lesquereux. They are also similar to plants collected by Dr. Richardson, in the Lignitic series of the Mackenzie River, as described by Heer, and represented by specimens in the collection of the geological survey, &c. They also approach very closely the so-called Miocene floras of Alaska and Greenland, as described by Heer, and in their facies, and in several of their species, they coincide with the Miocene floras of Europe." He then adds, "If we were to regard the affinities of the plants merely, and to compare them with the Miocene of other countries, and also to consider the fact that several of the species are identical with those still living, and that the whole facies of the flora coincides with that of modern temperate America, little hesitation would be felt in assigning the formation in which they occur to the Miocene period. On the other hand, when we consider the fact that the lower beds of this formation hold the remains of reptiles of Mesozoic types; that the beds pass downward into rocks holding Baculites and Inocerami; and that a flora essentially similar is found associated with Oretaceous animal-remains, both in Dakota* and Vancouver's Island, we should be inclined to assign them at least to the base of the Eocene.

From this it seems that Professor Dawson does not separate the two essential groups of the Tertiary: the upper one with its Miocene types, a flora indicating a temperate climate like that of the middle zone of the United States; the lower one with its numerous species of Palms, of Ficus, &c., evidently representing a subtropical vegetation. In this last flora, the one which is now under examination in this paper, there is no species identical or analogous to any of those of the Dakota group.

* The assertion is right for Vancouver's Island but not for the Dakota group.

The extraordinary separation of both floras has been sufficiently established by former comparison and descriptions of species. In the upper stage some rare types of the Cretaceous re-appear. But apparently the specimens obtained by the survey mostly represented the upper stage of the Canadian Lignitic. For Professor Dawson describes and enumerates, from Porcupine Creek, seventeen species, all of Miocene type, and most of them formerly described by Professor Heer and Professor Newberry, from the Miocene formations of Alaska, Greenland, and especially from the Union group, with which the Porcupine Creek group appears closely allied. These plants are:

- Equisetum* species, similar to *E. arcticum* Heer.
- Glyptostrobus* European, Heer.
- Sequoia* Langsdorffii Brgt.
- Taxus interrupta* Newby.
- Pterispermis*? species.
- Salix* species.
- Populus* Richardsoni Heer.
- Corylus* rostrata Ait.
- Corylus* American. Walta.
- Diospyros* species.
- Rhamnus* concinnus, Newby.
- Carya antiquorum*, Newby.
- Juniperus* cinerea? or *J. bilinicca*, Ung.
- Viburnum* pubescens, Pursh.

To this and by comparison are added the species catalogued by Heer from Richardson's collection on the Mackenzie, which, says Professor Dawson, belongs to the same region. They are:

1. *Glyptostrobus* European Heer.
2. *Sequoia* Langsdorffii Brgt.
3. *Pinus* species.
4. *Smilax* Franklini.
5. *Populus* Richardsoni.
6. *Populus* arctica.
7. *Populus* Hookeri.
8. *Salix* Rheana.
9. *Betula* species.
10. *Corylus* Macquarrii.
11. *Quercus* Olafseni.
12. *Platanus* aceroides.
13. *Hedera* McClurii.
14. *Pterispermis* dentatus.
15. *Phyllites* aridens.
16. *Antholithes* amissus.
17. *Carpolithes* seminulum.

The species described in the same report from the lower stage of the Lignitic of Canada are fewer and apparently represented by more perfect specimens. They are *Equisetum Parlatoii*, Heer, of the Miocene of Europe, a species to which *E. Haydeni* of Carbon is closely allied. Its habitat is marked as Great Valley.

Lemna scutata sp. nov., abundant at the Bad Lands, and also at Point of Rocks.

Salix species, Bad Lands.

Rhamnus? Heer (Great Valley), species of the Miocene of Greenland.

Salix species, Newby, (Bad Lands), species of the Union group. *Sequoia*, an undescribed species (Great Valley), corresponding to the preserved part, to *R. Eridani* Ung., which is *Sequoia* *syn.*, a Miocene species of Europe and of the upper American Lignitic also.

Trapa antiquus, *Trapa borealis*, and *Carpolithes*, three new species, described from obscure specimens, from the same locality as that of *Sequoia*, the Bad Lands, west of Woody Mountain.

From the exposition of this flora, it is not surprising that Professor Dawson should admit, as the result of his study of the fossil plants of the Lignitic, the Tertiary age of these formations. For, indeed, in this there is, as remarked already, no trace of any vegetable remains which, by comparison with the species of the Dakota group or with those of the Cretaceous of Europe, could be recognized as identical or related to any of them.

Coming back to the other plants of Point of Rocks, for considering their characters for an evidence of their age, by comparison with other groups of floras than that of Canada, we find in the table three of them marked as analogous to Cretaceous types. The first, *Pistia*, may be, as remarked in the description, an undeveloped or young form of *Lemna scutata*, a question here without importance. At first I considered this species as being the first of this genus recognized in a fossil state, for none has been published as yet. But Count Saporta informs me that a species, *Pistia Mayellii*, Sap. ined., has been found in the fresh-water Upper Cretaceous of Faveau, France. From the sketch kindly communicated by the author, his species appears very different in its characters from that of Point of Rocks. The generic affinity, however, is worth remarking, for a plant so profusely represented as is our species, which, by itself or mixed with *Lemna scutata*, covers both sides of a number of large specimens.

At the same degree of affinity, I have marked in the Cretaceous column of the table *Sequoia longifolia*, also found at Black Butte, and *Sequoia bifurcata*; the first on account of a distant likeness to *S. Smithii*, and the other to *S. Retkenbachii* and *S. rigida*, three species recognized, the first in the lower, the two others in both the upper and lower stages of the Cretaceous of Greenland. The wide distribution of *Sequoia* species is generally known; it is marked here by the presence of these two species in two stages of the Cretaceous. But without taking into account the longevity of these forms, we have to consider that if we have here two conifers merely related to Cretaceous species, we cannot eliminate the testimony of *Sequoia brevifolia*, which is as profusely represented in the flora of Point of Rocks as *Pistia*, and by specimens in a perfect state of preservation. One-half of the specimens of Mr. Oleburn, besides a large number of those of Professor Hayden, show its two somewhat different forms. As it is distinctly and easily determined, its characters being precise, and as this conifer is a representative of the Miocene flora of Greenland and of that of the Baltic, its fragmentary evidence is more positive than that of the two other *Sequoia* represented as yet by small fragments, and merely allied to Cretaceous species.

I consider as referable to the Eocene by analogy of distribution, *Salix* *syn.* and the two species of *Dryophyllum* of Point of Rocks. That they have originated in the Cretaceous is now an established fact. Schimper, in his Vegetable Paleontology, indicates as from Cretaceous formations two species of uncertain affinity. And nevertheless, in more recent work, the Flora of Gelinden, by Saporta and Marion, the authors remark that only species of Palms only was known by its fossil

of the Cretaceous. The recent discovery by Schweinfurth of *Sabal* in the Oretaceous, Heer, * in the Upper Oretaceous white chalk of Oase Chargeh, west of Thebes (about 25° latitude north), is evidence of the presence of palms in the Upper Oretaceous. The remains of this kind are extremely rare even at the end of the Oretaceous is proved by the importance attached to the discovery of this kind in a region under the tropic. From the Paleocene represented in the floras of Gelinden and of Sezane, no species of *Sabal* have been positively determined. For the fragments described in the last flora under the generic name of *Ludoviciania* are indefinitely referred either to the Pandanaceae or to the Palms. As yet, of the known fossil Palms from their fronds, twenty belong to the Oretaceous, especially to its lower stage; eight are described from the Tertiary without reference to any of its divisions, nine are Oligocene, and one Cretaceous. Of the eight species of *Sabal* described in the last flora is Miocene, two Oligocene, and five Eocene. *Sabal* *communis* Schp., and *S. precursoria* Schp., two species of the Upper Eocene of France, are very closely related, the first to *Sabal communis* of the other to *Sabal Grayana* found in many localities of the Lower Eocene of Mississippi to Vancouver. In considering the Lignitic flora of the Oretaceous of fossil plants from Black Butte, Golden, Colorado, and the Raton Mountains, &c., where the preponderance of remains of *Sabal* and *Flabellaria* is so marked, how could it be possible, if *Sabal* had no other characters for direction, to refer it to the Oretaceous? Above speaks plainly, and shows how I had to recognize the *Sabal* of Vancouver as Tertiary, from the numerous specimens of *Sabal* of Professor Evans from Nanaimo, even if the other plants of the *Sabal* had not represented Tertiary types. It was the same case for the *Sabal* of the Mississippi State, where the Palms are also in preponderance. Point of Rocks, four large specimens upon sandstone represent the species of *Sabal* as that of Vancouver and Mississippi, *S. Grayana*. In the opinion of a celebrated European paleontologist, is one of the most and most positively characterized species of the genus. The two species of *Dryophyllum* described from Point of Rocks indicated in the table of distribution as analogous to the Eocene genus represents a separate section of the oaks, corresponding to the form of the leaves and the indentations of their borders to the *Quercus* of the present North American flora. Messrs. Debey and Schimper have separated it for the classification of some leaves found in the Cretaceous of Belgium. It represents, therefore, a Cretaceous type, however, like some others of the same formation, *Fagus*, *Platanus*, does not appear to have reached its full development from or at the time. We see it, for example, in the Dakota group flora, in the proportion of two species in about one hundred and thirty, while in the Paleocene of Gelinden it has four species in thirty, and the same number in eight in the flora of Sezane. It then re-appears by more or less of our representatives in analogous species of *Quercus*, and may be followed nearly without interruption to the present time. It is clear that the reference of fossil species of this genus, as remarked in connection with remains of Tertiary plants, should appropriately pertain to the Eocene than to the Oretaceous. The presence of species of *Dryophyllum* in the Point of Rocks, and that also of *Pittia*, *Sequoia biformis*, and *Sequoia longifolia*

points to it an odd physiognomy, it is either as remnants of the past, merely recording a few features of old generations passed away, or as contemporaneous long persistent types, which do not distinctly characterize any peculiar epoch. As proof of this assertion we have the true Lower Eocene character marked in the same flora of Point of Rocks by our species, *Ficus planicostata*, *Viburnum marginatum*, *Populus meserioides*, and *Greviopsis Cleburni*, which evidently, related to species of the Sezane flora, though in various degrees, have no affinity whatever to Cretaceous types.

The flora of Point of Rocks is related to that of Black Butte by nine botanical forms or by one-third of its species. In considering the evidence of synchronism, the identity of two floras could not be more positively proved than this, and nevertheless we have here two to three thousand feet of interposed measures. It is a remarkable fact, upon which we will be remarked presently. The group of plants at Point of Rocks, besides the Eocene representatives, six species identified with, and many related to those of the Miocene of Europe. Therefore we see what has been remarked in other localities of the Lignitic, a compound or admixture of old and young tertiary types, in comparison at least with the fossil floras of Europe, and thus a general character which does not distinctly relate to any peculiar stage of European Tertiary. We have the Paleocene by relation to species of Sezane; the Upper Eocene, especially the Ligurian or Oligocene, by the Palms, and the Miocene by a number of common and generally distributed forms which, like *Sequoia langsdorffii*, *Populus mutabilis*, *Ficus tiliaefolia*, *Cinnamomum meseriense*, *Rhamnus rectinervis*, *Juglans rugosa*, &c., are omnipresent and constant types, indicating merely the Tertiary age for the Lignitic flora. For this reason I shall continue to carefully record its points of affinity with the divers groups of the geological floras of Europe; but at the same time denying as yet sufficient evidence of identity to any of them. I must to consider it simply as the Lower Eocene flora of this continent. I said above that the identity of specific forms at Point of Rocks and Black Butte was worth recording more carefully, as a remarkable case in regard to the distribution of plants. In marine strata the long preservation of types is a matter of little concern, for the circumstances under which the marine faunas are distributed may be the same for very long periods, as, for example, the mineral elements entering into the compounds, the depth and temperament of the water, &c. But that a comparatively large number of land or fresh-water plants, subject to modifications or forced to migrations by atmospheric changes, may be preserved identical through the lapse of time indicated by the thickness of the measures heaped along Bitter Creek, has not been proved by as positive evidence as we have it here. The distance between both localities is seven miles only, and the superposition of the strata is all along so clear, that there is no possibility of any mistake in the calculation of the vertical space separating both points. It is scarcely possible to hazard a conjecture upon the length of time indicated by the building up of these intermediate measures. Evidently of a shore formation, the heaping of their materials may have been more rapid than for the deposits on the wide bottom of the sea. They evidence, however, in their succession, a series of sandstone beds which though of greater thickness are interstratified by beds of clay, built up of swampy deposits of long duration and especially of coal-beds, still more clearly denoting the slow progress of the work.

A geological fact like the one remarked between the relation of the floras of Point of Rocks and Black Butte and the positive evidence of the

* Über fossile fruchte der Oase Chargeh, O. Heer, in Denks. der Schweiz. Gesells., vol. xrvii, 1876.

long periods of time and formations which separate them is an important document, whose importance as point of comparison in the geographical distribution of our present flora and of its ancient types will be easily accepted by botanists. But here it must be considered merely in connection with the question of the age of the Lower Lignitic.

The Cretaceous Dakota group is separated from Point of Rocks by a thickness of strata about the same as that which is marked between Point of Rocks and Black Butte. Nevertheless, between the flora of the Nebraska and Kansas Cretaceous and that of Point of Rocks and Black Butte, we find scarcely any analogous type, and not a single identical form. The erosions may have indeed considerably disturbed the marine strata representing the Cretaceous above the Dakota, but that cannot lessen the strength of the deduction made from the total disconnection of two floras, one of which denotes by its characters a marked dissimilarity of atmospheric circumstances. A weighty evidence, if not a positive proof, of a change of epoch, if not of the sea, at least upon the land. It is useless to repeat that, as yet, no marine invertebrate remains of Cretaceous type have been discovered in the whole Lignitic measures above Point of Rocks. We may add, however, that while the Tertiary age was, at its beginning, represented by a land formation, as seen by its flora, a Cretaceous marine fauna still locally persisted in deep seas. Facts of this kind are peculiar to European geology. The presence of the Saurian *Agathasaurus* in the Lignite bed of Black Butte is then certainly explainable as denoting the wandering of that animal out of its domain, and its death by peering into a peat-bog and being irretrievably swallowed by its soft interior. If once imbedded in soft peat, no animal, not even man, can get out of it. By this fact, and also from the reason that the coriaceous remains of plants of the bogs are not food for mammals, I explain the accumulation of bones of Eocene animals in the lower beds of the Lignitic. As a formation, a surface covered with deep bogs surrounded by sand and gravel, a primitive land would not afford food to mammals or even be accessible to them. Every one who has explored a peat-bog knows how the formations are deprived of animal life. Very few bones of *Aurochs* have been found in the bogs of North Germany, and the Lignite covered by the Lignitic shows how compact and continuous, not to speak of universal, were those swamps of the Lower Tertiary. I believe, therefore, that if the bones of Eocene mammals are not discovered in the lowest part of the Lignitic, they will be found in the upper strata. Moreover, the agglomeration of bones in certain localities depends on local circumstances, and do not immediately and forcibly relate, like the general characters of a whole period.

The question of the subdivision of the Lignitic or Tertiary measures which I have separated in four groups, from the non-coincidence of the general character of the flora, is still disputed, and this division is contradicted by the assertion that the discordance is merely apparent, and a result of the geographical distribution of species, as we see it now in groups of plants at distant localities. The comparative rarity of the fossil floras is not merely marked by the identity of species, but also by a kind of general character denoting the climatic circumstances. The modification due to the geographical distribution may be easily recognized by the presence or absence of a number of species in the flora of the Bitter Creek basin, of the Colorado, the Raton Mountains, the Lower Union group, the Mississippi, and Vancouver. There is between these localities a wide

space; and, indeed, the Vancouver flora may show, in its details, marked dissimilarity to that of the Mississippi. But, one of the prominent characters of the Lower Lignitic is the predominance of Palms, and we find it manifest in all the localities named above. Indeed, I have found remains of Palm, especially of *Sabal*, whenever I have seen Lower Lignitic beds; and, as it has been remarked formerly, *Sabal Grayana* has been observed on specimens from Vancouver, Point of Rocks, Golden, the Mississippi, &c. With this there are, in all these floras, a predominance of sub-tropical forms, and the absence of northern types, rendering more evident their correlation in time. Sufficient details have been given on the species of the group, and on their distribution, in Dr. Hayden's former report (1873), p. 378 to 390.

The group of plants of the Evanston division has, as yet, no remains of palm-leaves, but fruits doubtfully referable to the Palm family; with this it has some of its species of leaves represented at Golden, and at Carbon. The general character of its flora does not indicate a high average degree of temperature as that of the Lower Lignitic. The group has been separated, as an intermediate one whose relation is now positively fixed now. According to Professor Cope's description, many of Eocene vertebrate animals have been found in connection with it. Its true horizon may be rendered more definite by further discoveries. In the group of Carbon the general character of the flora is evident, and its relation to the Miocene of Europe and of Greenland is exposed, not only by this general kind of related faunas, but also by a number of species, like *Platanus aceroides* and *Guillelma*,* *Acer*, *Populus arctica*, *Quercus dubium*, *Alnus Kefersteinii*, *Betula*, *Quercus*, *Corylus*, indicating, together with the total absence of Palms, a marked difference in the climatic circumstances governing the flora and that of the Lower Lignitic group. This difference, also, is not remarked at Carbon only. It is reproduced in the same degree, by general affinity and identity of species, in the flora of Coral-Hollow, San Joaquin County, and of Contra Costa, south of Mount Diablo, California; of Bridge Creek, John Day Valley, and of Blue Mountain, Oregon; of Bellingham Bay, of Alaska, as established by Heer's flora of that country, and therefore followed northward from Carbon to Greenland. Some of its types are so definite that a single specimen of a species of *Acer* or *Platanus* would suffice to positively identify this group as Miocene, just as a few specimens of *Quercus fuscicornis* proved the Eocene age of the Cascade Mountains of Oregon, whose formations were at first supposed to be Post-Tertiary or of recent origin.

A few words more will be sufficient to answer the other objections recorded at the beginning of this paper against the value of vegetable paleontology in its application to geology for the determination of the age of the formations. We know now well enough that remains of small plants are abundantly found in the land deposits of this continent. The result obtained from the onset of American researches in vegetable paleontology let us surmise what an immense amount of documentary evidence the after-coming geologist shall be able to gather in the same field. The authority of animal-remains shall continue undoubted as far as it refers to marine formations. But when land formations are to be considered, the authority should, when evident, be accepted as decisive.

The fragment of leaf found in connection with the bones of the Saurian at Black Butte, and considered, from the character of nervation of the middle of the leaf, the only part preserved, as doubtfully referable to *P. Guillelma*? was identified from better specimens, showing the outlines of whole leaves, as a new species of *Viburnum*, described in this paper as *Viburnum platanoides*.

There may be some exceptional cases where both kind of evidence may be in opposition, however, and afford reasons for dispute of authority. For example, no Cretaceous invertebrate marine remains have been found in the strata of the Lignitic, above Point of Rocks, nor in the Black Butte series above this point, nor in the whole extent of the Colorado Basin; hence the plants, being characteristic of Tertiary, the whole formation should be admitted as Tertiary, of course. But Vancouver shows, as far as its flora is known, identity of characters of its plants with those of the Lower Lignitic, as known from the above-named strata; its relation is therefore defined as land formation, and should be to my persuasion considered as evidence of synchronism, therefore of its Tertiary age, though the beds bearing Tertiary plants may be locally and casually overlaid by marine strata with Cretaceous animal-remains. This case has some analogy with that of the presence of the bones of a Cretaceous Saurian at Black Butte.

Conformability or unconformability of stratification proves very little in regard to the changes which are considered as indicating a new epoch or period. Of course the disturbances of wide-expanded surfaces of the earth modify in various degrees the atmospheric circumstances, and, to a less degree, however, those which govern the distribution of animals under water. Therefore the changes in the characters of the floras of the oceans may be more or less evident in correlation with these circumstances. But these are more generally so gradual that they cannot be remarked by traces of unconformability, and the consequences modifications of marine or land beings can be appreciated only at very long distances of time. Gradual changes of this kind seem to have progressed during the whole period of the Cretaceous formations of the West, from the base of the Dakota group to that of the Tertiary Lignitic, and later still; for in the whole vertical space occupied by the deposits, unconformability of strata is remarked. But the concurrence of gradual atmospheric modifications with those of the earth surface is distinctly recognizable in the general character of the flora of the lower Lignitic, compared to that of the Dakota group, this being of a temperate climate, while that of the Lignitic proves a subtropical one. Of course the life under deep seas cannot be modified in the same degree and in the same period of time. It is but very slowly influenced by land atmospheric changes, and from this there is in some instances between the inhabitants of the land and those of the sea, a forcible geological disconnection, like that exposed at Black Butte by the Saurian and the plant remains wherein it was imbedded.

Perhaps the more weighty objection against the deductions made from the characters of the Lower Lignitic flora is that of the unreliability of comparison between the vegetable types of both continents in relation to supposed synchronous epochs. From this objection I would add that we should not attempt, in regard to the distribution of North American fossil plant, to consider anything known of the geological relation of those of Europe. This objection appears at first trifling, and it seems that it could be answered by the mere assertion that as American paleontologists have constantly taken their points of comparison from Europe, in considering the relation of the animal remains to the age of the strata where they were discovered, vegetable paleontology should be allowed to use the same privilege; for no section of natural science can be defined and progress *a priori* or without a basis of comparison, and where to find any if the European scientific main should be closed. But in this objection there is something more than the mere privilege of comparison. It seems positive that from

first appearance the American land flora has a proper American character, recognizable not merely in differences, but in priority of types. I have already alluded to this phenomenon, which, though seemingly observable, in many instances, is, however, not positively ascertained as an actuality, and not referable to a principle of a general application. We have, as far as our knowledge goes, a precedence of vegetable Devonian types which are already seen in the Silurian; the Carboniferous, also, is recognized by remains of *Lepidodendron* as low as the Marcellus coal. The Sub-Carboniferous flora of this continent is mostly Devonian, as in Europe, and the Lower Carboniferous has a number of specific forms, considered by European authors as Permian. Farther up, the Trias is marked by its *Cycadeæ*, and the Cretaceous of the Dakota group is typically allied to the Miocene species, and still more to the present flora of this country. If it is so, the objection expressed above is a mighty one, for then our Lignitic flora might be of an older period and representative of an American Cretaceous formation, though having already the characters of European Eocene floras! We have, in this peculiar case, a point of reliable comparison which answers the objection. The flora of Point of Rocks, considered as Tertiary, is probably at the lowest stage of the formation. Its characters have been exposed in a table of comparison. Now, the floras of Gelinden, in Belgium, and of Sézanne, in France, are connected with strata acknowledged by stratigraphy and animal paleontology as of the oldest European Tertiary. And here as at Gelinden, for example, the Cretaceous type, represented by *Dryophyllum*, is far more evident than at Point of Rocks, and in the flora of Sézanne it is about in the same proportion as in that of Point of Rocks and Black Butte. In this case, therefore, no trace of precedence of vegetable types is remarked on this side of the Atlantic, and the floras of both continents, offering evident synchronism by stratification, and both animal and vegetable paleontology, may be considered as giving reliable evidence by the comparison of their characters.

It is claimed that the opinion on the Tertiary age of the Lignitic contradicts evidence admitted by the highest scientific authority. Though no personal opinion may be recognized as authoritative in science, we have, on the question discussed here, a concurrence of views expressed by Dr. Newberry for the Lignitic flora of the Union group of the Upper Missouri River, and by Prof. J. W. Dawson for that of Canada. These are certainly the highest authorities in this country. From Europe, the opinion of Count Saporta, who is deeply interested in the progress of the botanical paleontology of this country, is not less explicit. After the examination of some of the plates prepared for the flora of the Lignitic, he writes: "That *Sphenopteris Eocenica* is closely allied to *Asplenium Wegmanni*, Brgt., of Sézanne; that species analogous to what I have described as *Abietites dubius* and *Abietites setigera* have been found in the Upper Cretaceous of St. Paulet, France; that our Palms, especially *Palmaefolius Goldianus*, denote Eocene; that the magnificent species *Sabal Grayana* is allied to, and perhaps an ancestor of, *Sabal major*, which in Europe appears at the beginning of the Miocene; and that *Flabellaria communis* is extremely similar to *Sabal andegaviensis*, which is found in the Eocene Superior of the south of France, but which has not been figured till now." From all this and other points of affinity which the celebrated paleontologist of France makes in regard to the species of the lower group of the Lignitic flora, he concludes as follows:—"In re-

suming; and notwithstanding that *Adiantum*, which I consider as a Cretaceous type, your first group seems indeed to be legitimately Eocene, by its Ferns, its Palms, its coriaceous and prototypical *Populus*, its *Quercus*, and its *Viburnum*, as related to the Bézanne flora, and to the flora of its Palms to the Upper Eocene of Angers. If one would suppose this flora more recent than the Eocene, he would have to admit such a dissimilarity between Europe and America that every comparison of the floras between the geological stages of both continents should appear an impossibility." The assimilation of American species with a number of Miocene species published in Europe is considered by Saporta as doubtful and not quite conclusive; and he remarks, also, that, though his opinion on the age of the Lower Lignitic group is given according to present impression, the great geographical distance renders the similarities between compared localities very difficult to fix with precision, even in supposing them contemporaneous.

These quotations must be excused by reason of the importance given now to the question of the age of the Lignitic, which, controverted in various ways, demands light, and has to be considered in every possible point of view. The problem is not yet solved. Requested, as I am, to contribute a share in the discussion, by closely adhering to paleontological evidence, and exposing it as far as it is given by fossil plants, I have entered into details in order to show its weight. And no better opportunity could be afforded for this purpose than a review of the group of plants obtained from Point of Rocks by Dr. Hayden.

From the following descriptions it will be remarked that some of the specimens have been found and communicated to the survey by Mr. William Cleburn, of Omaha, a zealous explorer and student of the vegetable paleontology of the Western Territories.

Description of species of fossil plants from Point of Rocks.

1. *FUOUS LIGNITUM*, *sp. nov.*

Frond flattened, irregularly dichotomous; branches diverging obliquely; branchlets short, terminal, linear-divaricate, tufted, forking at the point.

The fragment figured is the only one of this kind in the specimens. It represents a species allied to *Sphaerococcus crispiformis*, Sternb., as described in Heer's Flor. Tert. Helv. (p. 25, Pl. IV, fig. 1), and still more, perhaps, to the living *Fucus canaliculatus*, Ag., very common along the coasts of the Baltic Sea, and also discovered in numerous specimens in the Tertiary of Spitzbergen. The base of the lowest branches is four millimeters broad, but the size of the branchlets diminishes nearly one-half at each dichotomous division. The terminal branchlets are only half a millimeter broad, fasciculate-dichotomous, short, split, or furcate at the point, and divaricate. The substance appears thin, membranaceous, and yellowish.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

2. *SALVINIA ATTENUATA*, *sp. nov.*

Leaves small, one centimeter or less in diameter, opposite, joined at the narrowed, slightly-pediceled base, round or broadly oval, indistinctly reticulate by vertical and parallel rows of quadrate, large cells, marked in the middle by black spots, formed by very small, close cells, or pores, without any trace of a middle nerve.

This new species is related by its reticulation and its size to *Salvinia Mûlca*, Heer (Balt. Flor., p. 17, Pl. III, figs. 1 and 2), differing from

it by broader, less distinct, square areolæ, the absence of a dividing middle nerve, and the narrowing of the base to a very short pedicel. By these two last characters, this species is unlike any of this genus. It is, however, probable that the two leaves representing it were not, when embedded into the clay, in their full state of maturity, one of them being smaller than the other, and its areolation far less distinct. In the young leaves of the living *Salvinia natans*, the leaves, before attaining their full development, have the middle nerve scarcely discernible.

HABITAT.—Point of Rocks, William Cleburn.

3. *SELAGINELLA ? FALCATA*, *sp. nov.*

Frond small, dichotomous; pinnae narrow-linear, one to four centimeters long, six to seven millimeters broad; pinnales close, two-ranked, in right angle to the rachis, generally covering each other at the borders, falcate upwards, lanceolate-acuminate, suddenly narrowed to the point of attachment, without distinct middle nerve.

I have figured four different parts of this plant, which is abundantly scattered among the floating rootlets and upon the specimens of the *Lemna ? Scutata*. It may represent some kind of floating fern, perhaps, rather than a species of *Selaginella*. It is, however, closely allied to *Selaginella Berthoudi*, Lsqx., described in Dr. Hayden's Annual Report for 1873 (p. 395), differing, however, by the two-ranked position of the leaves and their distinctly falcate form.

HABITAT.—Point of Rocks, Dr. F. V. Hayden, W. Cleburn.

One of Mr. Cleburn's specimens represents a fragment of a stem ten centimeters long, one centimeter broad, round, but flattened by compression, covered with densely imbricate leaves of the same form and size as those of the branches. This stem proves the relation of the described fragments to the lycopodiaceous family.

4. *SELAGINELLA LACINIATA*, *sp. nov. ?*

Branches dichotomously divided; divisions two to three centimeters long; leaflets opposite, distichous, divided from the base in three to five filiform laciniæ, some of them forking at the middle, all curving upward, or falcate.

By its mode of vegetation, the form and divisions of the pinnae or branchlets, these small plants are exactly similar to those described from Dr. Hayden's specimens under the name of *Selaginella falcata*. The difference is in the remarkable laceration or thread-like divisions of the leaflets. The laciniæ distinct and in relief upon the stone are like the veinlets of fern-leaves, when, by maceration and decomposition, their epidermis has been destroyed, or like skeletons of leaves. In this case, however, as these thread-like branches are more or less numerous, either simple or forking from the middle, and thus differing in number and mode of divisions for each leaflet, this appearance cannot result from decomposition in water. It is probable that these remains represent a kind of lycopodiaceous plant, living sometimes partly immersed, and that, as it happens in numerous species of water-plants of this epoch, the immersed leaves become decomposed, and grow into lacinate divisions, while the emerged ones are entire or undivided. This difference in the leaves is particularly marked in *Nasturtium lacustre*, Gray, known to every botanist. I do not know, however, any Lycopodium species showing this kind of variations in leaves. Even *L. undatum* has the leaves of the immersed part entire or without divi-

long. It is therefore uncertain if the specific separation of these forms is authorisable.

HABITAT.—Point of Rocks, *William Oelburn*.

6. *SEQUOIA BREVIIFOLIA*, Heer.

Branches flexuous; branchlets opposite or alternate, open, bearing the base, then curving upward and erect from the middle to the top. Leaves of two kinds, either small, short, scalliform at the base of the branchlets and covering the whole of them when young, or enlarged in the middle, obtuse or abruptly narrowed to a point, gradually and slightly so toward the decurring base, distichous, decreasing in length toward the base and the top of the branchlets. We have a large branch* and numerous more fragmentary specimens of this species described by Heer in *Flor. Arct.* (p. 93, Pl. II, fig. 1), from Greenland specimens, in *Flor. Spitz.* (p. 37, Pl. IV, figs. 2, 3), from Spitzbergen specimens, and formerly in *Fl. Baltica* (p. 21, Pl. III, fig. 1). It is well characterized by the form of its generally short, open, distichous leaves, either abruptly pointed, or obtuse, deeply narrowed slightly decreasing in width from above the middle to the base. We have, however, a number of specimens with somewhat narrower, more linear, longer leaves, which show a notable deviation of the normal form. One of this species is not known as yet. One of the specimens bearing scattered branchlets and leaves of this *Sequoia* has a cone, which appears to be a flattened cross-section, or perhaps the flattened base of the cone turned upward, the pedicel marking the central point, and which the scales, oblong, cuneate, narrow, emarginate at the top, are imbricated to the borders. These scales rather resemble those of a *Glaucostrubus* than those of a *Sequoia*.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*, *Wm. Oelburn*, whose collection has about one-half of the specimens representing this species in its normal form, and its variety.

7. *SEQUOIA LONGIFOLIA*, Lsqx., MSS.

Branches thick; leaves closely appressed, erect, long linear lanceolate-pointed or acuminate, enlarged above the slightly contracted and decurring base; scars deep, lingulate-pointed, marked by a deep groove in the middle.

This species was already described from Black Butte specimens; these have, some of them at least, longer leaves than those of Black Butte. In these, the leaves average two and a half to three centimeters long and three millimeters wide; in those of Point of Rocks, the leaves, of the same width, are generally five centimeters long, even more. In both forms they are marked by a broad indistinct middle nerve, and the surface seen with the glass, appears very thinly striated in the length. This character, as well as the thick consistence of the leaves, seems to prove the identity of the species, though the leaves of the specimens of Point of Rocks are not only longer but proportionally narrower and scarcely contracted to the point of attachment to the branches. In both, the leaves are generally crowded and covering the stem.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*.

8. *SEQUOIA PIFORMIS*, *sp. nov.*

Stems thick, pinnately branching; branchlets short, obliquely diverging; leaves either linear or somewhat broader in the middle, gradually

nally narrowed to a point, slightly contracted to the decurrent base, slightly incurved or falcate, sometimes erect and appressed to the stem; scar-leaves triangular or lingulate-pointed.

This species apparently bears two kinds of leaves, even upon the same specimens; either long, two centimeters, and very narrow-linear, less than one millimeter wide, or shorter and broader, decreasing gradually from the base to the point, linear-lanceolate, nearly one and one-half millimeters wide and only eight to ten millimeters long; the middle nerve is deeply marked upon both kinds of leaves. I should have considered the numerous specimens bearing branches of this *Sequoia* as representing two species, the one with narrow longer leaves, the other with shorter broader leaves. But even the difference in the length and proportionate width of the leaves is distinctly perceivable upon one of the specimens, and the difference also in the length of the leaf, of the same width, is evident upon another. There are, moreover, a large number of specimens, all fragmentary indeed; and the difference in regard to the size of the leaves is apparent upon most of them. In the average, the leaves are much narrower than those of *Sequoia Batschimbachi*, Heer, to which this species is related by the falcate form of some of the leaves.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*.

9. *WIDDRINGTONIA COMPLANATA*, *sp. nov.*

Stem thick, disticho-pinnate; branchlets short, thick, alternate, oblique; leaves small, in spiral order, closely imbricate and appressed, oblong-lingulate pointed upon the primary branches, ovate-pointed or rhomboidal and shorter upon the obtuse branchlets.

This species, represented by many specimens, is evidently related to *Widdringtonia antiqua* (Sap. Et., 2, 1, p. 69, Pl. I, fig. 4), for the form of the leaves, which are, however, more closely appressed in the American species, and more distinctly placed in spiral order around the branchlets. These leaves do not appear of a thick substance, the coat of coaly matter over them being extremely thin.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*, *William Oelburn*.

10. *PISTIA CORRUGATA*, *sp. nov.*

Leaves thick, at least toward the base, varying in diameter from two to three and one-half centimeters, broadly obovate, generally bordered from above the base by a wavy margin two to five millimeters broad; gradually narrowed into a short pedicel about three millimeters thick, terminating into a bundle of radicles; veins emerging from the pedicel in two or three thick bundles, dividing and diverging from the base of the leaves, and forming in ascending, by a kind of abnormal anastomosis, irregularly polygonal meshes.

These leaves, resembling in form a small bladder, contracted on one side, seem somewhat inflated, or at least thickened, from the base to above the middle, or composed of two distinct areas, the lower one circular and separated by a narrow groove, or deep line, from the wrinkled border which surrounds it, narrowing, however, gradually toward the pedicel. The areolation of this border seems disconnected and distinct, representing large quadrangular areolæ, whose subdivisions curve along in festoons. Sometimes, however, the central part is not inflated, or thicker, and in this case, as in specimens representing young leaves, no traces of borders are perceivable. This groove, therefore, and the separation of the leaf in two distinct parts, may be caused by a kind of fold

* A beautiful specimen, the property of Mr. E. H. Clarke, agent of the Union Pacific Railroad, who kindly lent it for illustration of the species.

around a tergescence of the lower part, formed by an abnormal growth of radicles. The upper surface of the leaves is somewhat rough; the lower surface, inside of the fringe, is dotted with minute holes, or like spongy. The leaves are generally mixed, or superposed to thin foli-ferous long radicles, all of the same size, coming in bundles from linear petioles, two to five millimeters thick. They form a thick coating surrounding the leaves, or whereupon the leaves are floating, without evident connection or point of attachment to them.

At first I supposed these leaves as representing the same species as the following, but their relation to species of *Pistia*, whose leaves are flat and not like vesicles, seems to indicate, though the likeness in some of the characters may be, that these organs represent two kinds of water-plants. Comparing this one to leaves of *Pistia spathulata*, Mich., from specimens of Louisiana, the affinity is remarked not only in the obovate shape of the leaves, but in the kind of nervation, by inflated primary veins diverging from the base of the pedicel, where they pass into bundles of radicular filaments of the same characters as those of the fossil plant. Most of the leaves of the living species, the old ones especially, bear from the middle to the base an inflated spongy coating similar to that which is observed on the under surface of the fossil leaves. The more marked difference is in the central part of the fossil species, which appears surrounded by a distinctly-marked deep line, while in the leaves of *P. spathulata* the thick zone, though definite, terminates in passing upward along the primary veins; but this difference, like that of the areolation along the borders, is specific only and the generic identity appears clearly defined.

HABITAT.—Point of Rocks, very abundant, and covering by itself only large surface of shale, Dr. F. V. Hayden, Wm. Cleburn.

10. LEMNA SCUTATA, Daws.

Fronds round, entire, slightly undulate on the edges, sometimes an inch in diameter, single or grouped; roots numerous, filiform, proceeding from a round spot near the notch of the frond.

To this species, as described and figured by Professor Dawson (Report on the Geology of the Forty-ninth Parallel, Appendix A, p. 329, Tab. XVI, figs. 5 and 6), I refer a number of round bodies, leaves or fronds, mixed with the species described above. Comparing them with the author's figures, there is no difference whatever, except that if some of them do not show any trace of veins, others, exactly of the same shape, are veined from the base, where the radicular filaments are attached to them and the veins distributed as in the former species. Some specimens, one of which has been figured, show the basilar part inflated, on the pedicel wherefrom the veins are diverging, just in the center of the circular organism, as if it had been a bladdery or vesicular plant, flattened by compression. I still believe that both the leaves described above and these represent the same kind of vegetable, these being the young and yet undeveloped organs. All the different appearances of these plants, represented by numerous specimens, have been figured, and comparison of their various forms will, I think, satisfy paleontologists as to their relation to a species of *Pistia*.

HABITAT.—Point of Rocks, mixed with the former, Dr. F. V. Hayden, Wm. Cleburn.

11. OTTELIA AMERICANA, sp. nov.

Spathe ovate narrowed to a round pedicel, surrounded by an undulate and wrinkled fringe, emarginate at the top.

The central part of this organism, representing the spathe of a water-plant, is oval, somewhat inflated, narrowed to a round pedicel, and surrounded by a margin or fringe half a centimeter broad, cut or emarginate at the top. The middle part is slightly inflated and striate in the length. The border fringe is opaque, and does not show any appearance of nervation. Comparing it to a figure of *Ottelia alismoides*, Pers., from Ceylon, kindly communicated by Saporta, the fossil plant seems in perfect concordance of characters with the living.

HABITAT.—Point of Rocks, Dr. F. V. Hayden, represented by one specimen only, in a good state of preservation.

12. SABAL GRAYANA, Lesqx.

Trans. Am. Philsoc., vol. xiii., p. 412, T. xiv., figs. 4-6.

Frond apparently large, represented by fragments only; rachis flat, elongated linear-acuminate, six to eight inches long, enlarged at its base and rounded on both sides; rays numerous, gradually enlarging upward, half to two and one-half centimeters broad, marked with distant and distinct slender veins. The characters of this species have been described in detail as quoted above. The species is always easily identified by its slender though distinct and equally distant veins.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

13. DRYOPHYLLUM ORENATUM, sp. nov.

Leaves oblong, lanceolate, abruptly oblique to the petiole or subtruncate; borders deeply, regularly crenate; substance of the leaves somewhat thick, subcoriaceous; surface rough; nervation pinnate, middle nerve flat and broad, lateral veins diverging sixty to sixty-five degrees, flat, distinct, slightly curving in ascending to the borders subcamptodrome, the veins forking up under the sinuses of the teeth, and a branch passing up along the borders from the point where the veins enter the teeth; nervilles thick, in right angle to the veins, forming, by subdivision and anastomosis, a square or indistinctly polygonal areolation.

Of all the species described of this genus, none is comparable to this one, which is especially distinct by its broadly obtusely dentate borders. It is represented by two fragmentary specimens.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

14. DRYOPHYLLUM SUBFALCATUM sp. nov.

Leaf subcoriaceous, linear-lanceolate, acuminate or sharply pointed; borders regularly serrate with short blunt teeth turned upward; lateral veins parallel, diverging thirty to forty degrees, straight to the point of the teeth; fibrillæ close, thin but distinct, simple or ramified in the middle, the upper ones joining nearly in right angle, a branch veinlet which pass from near the point of the lateral veins under the sinuses, and follows along and close to the borders.

There is only a fragmentary specimen of this species, the upper half of a leaf. By its form and nervation, it seems at first referable to the genus *Castanea*, and, truly, it would be easy to find leaves of the present *C. vesca* apparently perfectly similar to this fossil one. There is, however, a difference in the areolation, or in the arrangement of the tertiary veins. In these primary types of *Quercus* and *Castanea* described under the name of *Dryophyllum*, the upper branch of the secondary veins passes from near the point of the vein under the sinuses and closely follows the borders, which thus sometimes appear narrowly marginate, and is joined nearly at right angle by the upper fibrillæ. This charac-

ter, though still indistinctly traced in the leaves of *Castanea*, and of some species of chestnut-oaks, is far less regular, the upper branches which follow the borders being of various sizes, not so exactly parallel to the borders, and not in close proximity to them. This new species is intimately related to *Dryophyllum Dewalquei* Sap. & Mer. (*Flor de Golden*), especially to the fragment figured in Pl. III, Fig. 2. It differs only by the shorter, less acute teeth of the borders, the slightly falcate form of the leaf, and the close thin fibrillæ.

HABITAT.—Point of Rocks, Wm. Oleburn.

15. *POPULUS MELANARIA*, Heer.

Leaves with a long, slender petiole; deltoid, subtruncate at base; borders acutely serrate; primary basilar lateral nerves emerging from above the border base of the leaf, with a pair of thin marginal veinlets underneath.

Considering what can be seen of this leaf from the fragment which represents merely its lower half, with the long, slender petiole, the distinct nervation, and a few of the border-teeth, it exhibits characters in accordance with those described above, and translated from Schimper's Vegetable Paleontology, and especially with the figure given of this species in Flor. Tert. Helv. (Pl. LIV, fig. 7). Professor Herr remarks, that it essentially differs from *Populus latior*, var. *subtruncata*, by the position of the lateral primary nerves at a distance from the border-base of the leaves. In the leaf figured as indicated above, this distance is still greater than in that in the Flor. Helv. Heer remarks also that he has seen a large number of specimens of the same species, but that in all except one, which he has figured, the upper part of the leaves was destroyed, as it is in ours. He mentions as distinctive characters, the acutely serrate borders of the leaves, and the middle nerve thicker than the lateral ones, the same as seen upon our specimen. I have, therefore, no doubt about the relation of this leaf to the European species.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

16. *POPULUS MELANARIOIDES*, *sp. nov.*

Leaf subcoriaceous, nearly round, subtruncate at base, long-petioled; borders undulate; nervation ternate from above the base of the leaf, secondary veins two pairs, at a great distance from the primary ones, these much branched outside; the others simple, all the divisions passing to near the borders, where they become effaced in the areolation; nervilles thick, flexuous, in right angle to the veins, forming by ramification at right angle square polygonal meshes.

By the subcoriaceous substance, the long slender petiole of the leaves, this species is referable to the section of the *Trepidae* (Trembling Poplars). As in *Populus tremulæfolia*, Sap. (Et., 3, 2, p. 26, Pl. III, fig. 4), to which this species is allied, the veins and their branches pass through the areas to very near the borders, which they seem to reach. The American form differs merely by less-distinctly undulate borders, the distance of the primary lateral nerves above the base, and by the great distance of the secondary veins. These two last characters are, however, of no moment for the specification of poplar-leaves, as can be remarked in the examination of a few leaves of the too common *Populus alba*. In fossil species, *Populus Massiliensis*, Sap. (Et., 3, 2, p. 30, Pl. II, fig. 6), is represented by three leaves, each of a different character of nervation. The relation of this species with that of the Tertiary

(Miocene?) of Provence, described by Saporta, may be therefore more intimate than it appears from the comparison of a single leaf. Our species is also comparable to *Populus heliadum*, Ung., by its form, and to *P. melanaria*, Heer, by its nervation.

HABITAT.—Point of Rocks, Wm. Oleburn.

17. *FICUS ASARIFOLIA*, Ett.

Leaves petioled, broadly reniform, subcordate or subpeltate, very obtuse, small, with borders crenulate; primary nerves palmately five to seven; middle nerve straight; upper lateral ones strong, curving inward, branching and anastomosing with the upper secondary veins; veinlets transversal, their ramification forming a protuberant, or embossed, very distinct, polygonal areolation.

Though this species has been already briefly described from specimens found at Golden, in Dr. F. V. Hayden's report for 1872 (p. 378), it had as yet not been figured, the fragments of leaves being generally too incomplete. It is, however, easily recognized by its peculiar nervation, forming small, elevated, polygonal areolæ, an areolation like an embossed checker-board, resembling that of *Asarum Europeanum*. The fragments of Golden seem to be part of much larger leaves than those of Ettinghausen, who described the species in Bilin Flora (p. 80, Pl. XXV, figs. 2-3). These *per contra*, from specimens of Point of Rocks, are perfectly well and entirely preserved leaves, rather smaller, except one, than the leaves of Bilin. They are also slightly more expanded on the sides, or reniform, and the crenulations less distinct, but these border-divisions are, for their size, related to the areolation, which is wider in proportion of the size of the leaves. Our leaves, also, are evidently peltate, at least in two of the figured specimens. One only has the position of the thick petiole marked similarly to that of the European leaves; but even the representation of the species by the author seems to indicate peltate leaves, whose borders are erased at the base or at the point of attachment of the petiole. The differences are too unimportant to be considered as specific characters. These leaves merely represent a local variety, or a *var. minor*. This species appears to be rare in the Tertiary of Europe, as it has till now been seen only in the plastic clay-beds of Bilin.

HABITAT.—Point of Rocks, Dr. F. V. Hayden, Wm. Oleburn.

18. *FICUS DALMATICA*, Ett.

Leaves narrowly ovate, obtusely pointed, narrowed to a short petiole; middle nerve thick toward the base, thinning upward; basilar lateral nerves, from above the border-base of the leaves, thin, ascending at an acute angle of divergence of thirty degrees to the middle of the leaf; secondary veins more open, equidistant; nervation camptodrome, joined by transverse nervilles.

In considering the figure by the author in Flora Promina (Pl. VII, fig. 11), there is no difference whatever between the European form and ours; but the description says that the secondary veins are branching at the point, and there is no trace of divisions of veins observable upon our specimens. As, however, the figured single leaf shows merely transverse nervilles and not real branches, and as these nervilles are also visible on the American form, it is apparently identical. One of the leaves represented in our plate seems rounded at the base. This is caused by its reversal into the stone, the upper part of the leaf being flat and the lower curved down in entering the stone where the extreme base and petiole are imbedded.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

19. *FICUS PLANICOSTATA*, Lsqf.

Dr. F. V. Hayden's Report on the Geol. Survey of the Terr. 1872, p. 393.

A small leaf in a perfect state of preservation represents this species very common at Black Butte. It is easily recognized by the broadly ovate, thickish, entire leaf, slightly pointed or obtuse, rounded or subcordate at base, short-petioled, three-nerved from the top of the petiole, &c.

HABITAT.—Point of Rocks, Wm. Cleburn.

20. *FICUS TILIÆFOLIA*, Heer.

Like the former, it has been described previously in Dr. F. V. Hayden's Report for 1871, p. 287, from specimens of Washakie station; mentioned in supplement to this report, p. 12, from Evanston; p. 6, from Placière anthracite; in same report, for 1872, p. 375, from above the Gebrungs coal, near Colorado City; and p. 393, from Black Butte station. We have also specimens from Golden and other localities; for here, as in the Miocene of Europe, this fine species, so easily identified, is distributed through the whole thickness of the Lignitic, excepting, however, the upper stage, that of the Green River group, where it has not been found as yet. I have figured it from specimens of Point of Rocks, not merely because it is there clearly represented, but to show more evidently the relation of this locality with the Tertiary Lignitic.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

21. *FICUS IRREGULARIS*, Lsqf.

This species was published under the name of *Ulmus? irregularis*, in Dr. F. V. Hayden's Report for 1872 (p. 378), the generic reference being then uncertain. Numerous specimens obtained later from Black Butte, where the species is common, shows a thick inflated leaf-stalk, a character which indicates the relation to *Ficus*. The specimen of Point of Rocks is like the counterpart of one already engraved from Black Butte specimens; the identity of characters is unmistakable, and therefore it was figured also as another record of identity of the flora of both localities.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

22. *TRAPA? MICROPHYLLA*, *sp. nov.*

Leaves small, round, or broadly oval, obtuse, rounded to a short petiole, with borders denticulate from below the middle, three-nerved from the top of the petiole, or irregularly pinnately nerved; lateral veins at an acute angle of divergence, fifteen to twenty degrees, flexuous, with dichotomous branches, all craspedodrome; areolation by subdivision at right angle, polygonal, distinct.

These leaves vary in size from a little more than one centimeter long and nearly as broad to about two and a half centimeters long and nearly two centimeters broad. They are generally oval-obtuse, somewhat enlarged toward the round point; the borders are minutely dentate except at and near the base, rounded to a comparatively long and slender petiole, the only one of the leaves where it is preserved being eighteen millimeters long, and its petiole nine millimeters. The areolation is peculiar, in square or polygonal areolæ, formed by close, thick nervilles, anastomosing with veinlets parallel to the veins and their divisions, the areolation being clearly defined, and the parietes as thick as the veins. The same kind of areolation is remarked upon the lower surface of the leaves

of *Trapa natans*, which, though comparable to the fossil ones by the areolation, has its borders deeply toothed and a much thicker consistence. In this species, the leaves appear membranaceous and as pellucid, so distinctly marked in black appear the nervation and the areolation upon the yellowish substance of the leaves. These leaves are mixed with the filaments or rootlets described with *Lemna? bullata*, and represent evidently a kind of water-plant. No fossil leaves published as yet are, to my knowledge, comparable to these, except those described by Professor Newberry, in the Report of the Colorado Exploring Expedition by Lieut. S. C. Ives (p. 131, Pl. III, fig. 5), under the name of *Neuropteris angulata*. The outline or general form of the slightly dentate leaves, the pinnate nervation, and the remarkably acute angle of the secondary veins are characters common to both species; even the irregular though obscurely marked division of the secondary veins seems to be of the same kind. It may be remarked that Professor Dawson has observed and described a fruit of *Trapa* found in connection with his *Lemna scutellata*; therefore in circumstances similar to those where these leaves, referred to *Trapa*, are found.

HABITAT.—Point of Rocks, Dr. F. V. Hayden, Wm. Cleburn.

23. *LAURUS (PERSEA) PRÆSTENS?*, *sp. nov.*

Leaf coriaceous, large, broadly lanceolate or elliptical, narrowed upward to an acute point, and downward in the same degree to a thick, short petiole; middle nerve thick; secondary veins strong, parallel; nervilles distinct; areolation very small, lightly marked.

The very fine and well-preserved leaf is sixteen centimeters long from the base of the thick petiole, which is one centimeter long, five centimeters broad in the middle, where it is the widest, and has thick secondary veins regularly branching, with distinct nervilles and the areolation of a *Laurus*. The foliaceous substance of the lower part of the leaf is destroyed, but the middle thick nerve and the petiole are preserved, as well as the outline-borders. By its nervation, this species is allied to *Persea speciosa*, Heer, differing by the form of the leaf and the thick middle nerve. By these two last characters, it is comparable to *Laurus princeps*, Heer (Fl. Tert. Helv., II, p. 77, Pl. XC, figs. 17-20), differing, however, by the secondary veins somewhat thicker and slightly more distant. It is most closely related to the present *Laurus Canariensis*, Sm.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

24. *VIBURNUM ROTUNDIFOLIUM*, *sp. nov.*

Leaf nearly round, small, surrounded by a black border, slightly and distantly denticulate by extension of the borders at the point of contact of the secondary veins and of their branches, all craspedodrome; secondary veins open, diverging fifty to sixty degrees, equidistant, parallel, the two lower pairs ramified, the upper ones only forking near the borders; areolation distinct, from parallel distant fibrillæ, branching and anastomosing in large equilateral meshes.

The black borders of the leaves, the general characters of nervation, and the facies are the same as in the other species of *Viburnum* published from Black Butte. This leaf differs especially by its nearly round form, the base rounded to the petiole, the secondary veins more open, and especially the very small, slightly-marked teeth of the borders. But for this last character, this leaf could be referred to *Viburnum platanoideum*, Lsqf., as represented by the small leaf of Pl. XXXVIII, fig. 10, of the

of the Flora. In the secondary veins are, however, more or less distinct, and may be a more local variety.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

VIBURNUM WYATTI, Hay.

This species has been described in Dr. F. V. Hayden's Report for 1871 (p. 392), and referred, with some doubt, to the Greenland species described in Ant. Fl. Gr., p. 473, Pl. XLVI, fig. 13. The secondary veins in this species are distant and less regularly parallel. Though its relationship to the species is somewhat doubtful, it does not appear to differ, however, from that of Black Butte.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

VERONIA MARGINATA, Lsqx.

This specimen is fragmentary, but the species, very common at Black Butte, is recognizable.

HABITAT.—Point of Rocks, Wm. Cleburn.

DIOSPYROS BRACHYSEPALA, Al. Braun.

Described already in Dr. Hayden's Report for 1872 (p. 394), from specimens of Black Butte, and in Report for 1873 (p. 401), from specimens of Black Creek, Colorado, a locality identified with Golden by Dr. Hayden. Some of the leaves found as yet are as well preserved and are characterized as that of Point of Rocks, which is especially conspicuous in the leaves in Heer's Pl. Tert. Helv. (Pl. CII, fig. 2). The species is known in the Miocene of Europe, especially in the lower part of the Tertiary, and is equally widely distributed in our Lower Tertiary.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

GREVIOPSIS OLEURNI, sp. nov.

Leaves of medium size, subcoriaceous, ovate, rounded, and tapering to the base; short petiole; sinuate-denticulate, thickened at the base; primary veins thick; secondary veins, thick, distant from each other, and also from the primary veins, branching outside with subdivisions or veinlets entering the sinuses; venilles in right angle to the veins, flexuous, simple, or branching in the middle; areolation obsolete.

This fine leaf, about five centimeters long (the point is broken), and two centimeters broad in its widest part, below the middle, is so remarkably similar by its form, the denticulate borders, and the nervation, to *Greviopsis orbiculata*, Sap. (Sezane Fl., p. 411, Pl. XI, figs. 11 and 12), that its identity is positive. It specifically differs by its larger size, the distant veins, and the double ramification of the primary veins. The ramification is more distinct and more generally multiple, the branches fusing before reaching the borders and curving along the leaf, has, like those of the European species, a subbasal veinlet, which follows the borders, and is united by nervilles in right angle to the primary lateral nerves above.

HABITAT.—Point of Rocks, Wm. Cleburn.

RHUS MEMBRANACEA, sp. nov.

Leaves small, membranaceous, thickish, oblong, obtusely rounded or subtruncate at base, irregularly coarsely denticulate, veins open, the lowest decurving to the middle nerve, and the others more or less ramified.

In this species, there is the point of a leaf, and another one nearly opposite, though somewhat lacerated, about two and a half centimeters long, including the petiole (three millimeters), and one and a half centimeters broad, oblong or lingulate, with borders cut from the base, comparatively large, pointed teeth, either simple or with small serrations on the back of the largest ones; nervation craspedodromous; secondary veins entering the large teeth; and more or less irregular and obscurely dividing in very thin branches, joined in the middle, forming a large, scarcely distinct areolation. By the form of the leaves and the border-divisions, this species is comparable and closely related to *Rhus Pyrrha*, Ung., as figured in Tert. Flor. Helv. of Heer (Pl. CXXVI, fig. 20), which has leaves, round truncate at the base, and short-petioled, as in one of our specimens. Like *Rhus Pyrrha*, it is also comparable to *Rhus aromatica* Ait., a very common species of our present flora. This has also generally doubly dentate teeth, and, in southern specimens, a thickish, membranaceous consistence.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

JUGLANS RHAMNOIDES, Lsqx.

A small leaf of this species, which is not yet, however, definitely limited, as seen from the description in Dr. F. V. Hayden's Report for 1871 (p. 394), and which may be identical with *Juglans Leconteana*, Lsqx., and *Juglans acuminata*, Newby. Though it may be of the value of the species, the leaf from Point of Rocks is identical in all its characters, even in size, with some of those found in the burned beds of red shales at Black Butte.

HABITAT.—Point of Rocks, Dr. F. V. Hayden.

The three following species have been sent also by M. Cleburn from the Alkali stage-station, on the Sweetwater road, about thirty miles north of Green River station of the Union Pacific Railroad. The collector of the specimens did not himself visit the locality, but obtained them from another party, who did not give any details on the relative position of the beds where they were discovered. They represent three species, all new.

The character of the leaves, as also the presence of remains of *Palms* of the same locality, seem to indicate about the same station as that of Point of Rocks or Black Butte. They are described, therefore, as of the same group.

ALNUS UNEQUILATERALIS, sp. nov.

Leaves thin, variable in size, broadly oval or ovate-pointed, rounded at base, short petiole; borders crenato-serrate; nervation pinnate; lateral veins irregular in number and distance, curving in passing to the border at an angle of divergence of fifty to sixty degrees; and entering the leaf by their ends or by small branchlets, when they pass under the border and follow the borders.

These leaves vary in size from four to eight centimeters long, and from three to six centimeters broad, one of the sides measuring generally one-fourth in width more than the other. The irregularity in the number of the veins is correspondingly great; one of the leaves, the smallest example, has, on one side, five lateral veins, the lower most branched, and on the other, ten, all simple. The largest of the leaves of this species, which is represented by a number of specimens, is related by form and nervation to *Populus Lebrunii*, Wat., which Saporta

considers as referable to his *Alnus cardiophylla*. It is represented in the Sezane Flora (Pl. XV, fig. 8). The general facies of the American leaves is, however, different, the teeth being broader and more obtuse, the pinnation more distinctly pinnate, and the disposition of the veins to enter the teeth by their extremity more marked; and compared to *Alnus cardiophylla*, it is especially different by the constant inequality of the leaves. This last character and the irregularity of nervation are not of frequent occurrence in the leaves of *Alnus*. *Alnus viridis* and *A. serrulata* are, however, sometimes irregularly veined, and the inequality of the sides is seen in a number of fossil species, *Alnus cyclocladum*, Ung., especially *A. spradum*, Sap.

HABITAT.—Alkali station, Wm. Cleburn.

2. *JUGLANS ALKALINA*, *sp. nov.*

Leaves pinnately compound; leaflets lanceolate, tapering upward to a long acumens, either narrowed or rounded to a short petiole; borders crenulate; lateral veins distant, mostly alternate, parallel, separated by short intermediate tertiary veins, curving in passing toward the borders at an open angle of divergence, and ascending high along them in feeble tones; nervilles in right angle to the veins, branching in the middle, and forming, by subdivisions, irregularly quadrate or polygonal meshes.

This species is represented by four leaves, and its characters distinct. It is comparable to *Juglandites peramplus*, Sap., and *Juglandites cornutus*, Sap., both of the Sezane flora, partaking of some of the characters of both. It is, however, still more intimately allied to *Juglans Bilimbia*, Heer (Flor. Tert. Helv., III, p. 90, Pl. CXXX, figs. 5-19), from which it merely differs by the position of the lateral veins at a more acute angle of divergence following higher up along the borders, and by the thicker and more numerous tertiary veins.

HABITAT.—Alkali station, Wm. Cleburn.

3. *CARPITES VIBURNI*, *sp. nov.*

Seeds or nutlets cordate obtuse, five to seven millimeters long, three to four millimeters broad, convex, grooved in the middle from the point to the base, surrounded by a membranaceous pellicle, the remains of an apparently fleshy outer envelope. They resemble seeds of a similar kind which I have found in great quantity at Golden, and referred to the genus *Viburnum*. Their form is like that of the seeds of *Viburnum Whymperi*, Heer (Spitz., Flor., p. 60, Pl. XIII, figs. 22 and 27).

HABITAT.—Alkali station, Wm. Cleburn.

NEW SPECIES OF TERTIARY FOSSIL PLANTS BRIEFLY DESCRIBED.

The following-described species have been discovered since the publication of the last annual report of Dr. F. V. Hayden's Geological Survey of the Territories. They are represented by specimens sent from different localities indicated, with each species, as well as the name of the discoverer. All these species have been figured for the second volume of the Contributions to the Fossil Flora of the Western Territories.

1. *SPHERIA RHYTISMOIDES*, *sp. nov.*

The spots formed by this small fungus upon the bark of some stems and the leaves of a *Myrica* are composed of circular perithecia, placed

five or six in a circle, forming thus a small crenulate ring. The perithecia become connected sometimes, apparently by decomposition; they are, however, generally separated. The size of the spots varies from one to two millimeters.

HABITAT.—Black Butte, upon *Caulinites Sparganioides*.

2. *HYPNUM HAYDENII*, *sp. nov.*

Stem rigid, sparingly divided in nearly opposite, short branches, inflated toward the top, or club-shaped; leaves closely imbricated all around, lanceolate-acuminate or sharply pointed, concave. Comparable especially to *Hypnum Boscii*, Schwgr., an American species of the present time.

HABITAT.—South Park, near Castello Ranch, Dr. F. V. Hayden.

3. *LYGODIUM MARVINI*, *sp. nov.*

A single leaflet of this fine species. It is simple, ligulate, obtuse, serrulate above, hastate at base; middle vein and veinlets distinct; veins forking once or twice. Allied to the living *Lygodium venustum*, which ranges from Mexico to Brazil.

HABITAT.—Top of gypsum series, Grand Eagle junction, A. R. Marvin.

4. *LYGODIUM DENTONI*, *sp. nov.*

Leaflets bi-tripartite, with short, obtuse divisions and broad sinuses, broadly triangular, rapidly narrowed to a subcordate or subtruncate base, entire, bi-trinerved from the base; primary nerves distinct, like the veins, which are forked once or twice, and become very close along the borders.

HABITAT.—Green River group, near the mouth of White into Green River, Prof. William Denton.

5. *GONIOPTERIS PULCHELLA*, ? Heer.

An intermediate form, represented by mere fragments of pinnae and separate pinnules. The shape of the pinnules united to the middle refers it to *G. pulchella*, while by the less pointed leaflets and the nervation it represents *G. Fischeri* of the same author.

HABITAT.—Golden, in sandstone, above coal.

6. *ZAMIOSTROBUS* ? *MIRABILIS*, *sp. nov.*

This species, whose reference to *Zamia* is not positively ascertained, is represented by a fragment, the half cross-section of a silicified cone, about fourteen centimeters in diameter. The outer surface is marked by the rhomboidal obtuse top of black seeds, or stony fruits, surrounded by a white vasculoso-cellular matter. In the cross-section of the cone, these seeds, of an enlarged rhomboidal form, three to three and a half centimeters long, six to eight millimeters broad, of the same size in their whole length, or slightly narrowed to the base, appear fixed or implanted into a zone of whitish, subpellucid mass of celluloso-vascular filaments. Under this ring of white matter, one centimeter thick, comes the central part, or axis of the cone, represented by mixed fragments of blackish opaque matter, agglutinated and amorphous. The fruits, or seeds, are represented by a black, compact, opaque silex, pierced in the length by large pores or ducts passing from the top to the base of the fruits. The intervals between them, nearly as large as the seeds, are filled by the same whitish celluloso-vascular matter which composes the white zone wherein the base of the fruits is embedded. The

figure only of the specimen can give a good idea of this fragment of cone. It is distantly comparable, for the form and the disposition of its surface-scars, to *Androstrobos*, a genus established by Schimper for some cylindrical cycadeous male cones, formed of imbricated scales bearing sessile anthers on their lower surface. For the position of the fruits, it has a distant relation to *Zamiostrobos gibbus*, Reuss., a cone which shows, in its section, oblong seeds, in right angle to the axis, with their tops appearing at the outside surface. Both these cones are figured in Schimper's Veget. Pal. (Pl. LXXII, figs. 1, 2, 14, 15). There is, however, a great difference in the very large size and in the characters of this silicified strobile with those of a *Zamia*. It apparently represents a peculiar genus of the *Cycadineæ*.

HABITAT.—Found loose around Golden, Dr. F. V. Hayden.

7. *SEQUIOA AFFINIS*, sp. nov.

Branches long, slender, pinnately branching; leaves short, oblong, imbricated and obtuse; or longer, lanceolate-acute, erect or slightly reflexed; branchlets bearing cones, open; strobiles small, round-oval, obtuse; scales large, rhomboidal, with entire borders, a central oval mamilla, and wrinkles passing from it to the borders all around; male branches erect, with more acute and open leaves, resembling sterile branches of *Glyptostrobos Europeus*, with small, round catkins, covered to the top by imbricated lanceolate leaves.

This species, of which we have numerous and admirably well-preserved specimens, is much like *Sequoia Coutsia*, Heer, of the Bovey-Tracy flora, differing, however, from it by the more obtuse point of the scale-like leaves, by more acute and longer leaves of the sterile branches, by more slender branchlets bearing cones at their ends, by proportionally larger, more oval cones (not globular), by the indistinctness of a middle nerve on the back of the leaves, which appear merely convex or inflated, etc. The seeds are of the same size as those of *S. Coutsia*; they differ also somewhat by a cordate base and a mere trace of middle nerve near the top, where it divides and passes on both sides, curving along the borders.

HABITAT.—Middle Park, Dr. F. V. Hayden.

9. *SEQUIOA ACUMINATA*, sp. nov.

The form of the leaves is about the same as in *Sequoia longifolia*; they are, however, generally shorter, narrower, less crowded upon the stems, and especially distinct by the smooth surface of the leaves. In this species, the denudated branches are striate, while, in the former, they bear the scars of the base of the leaves. This difference, however, may be merely the result of decortication in the specimens representing this last species.

HABITAT.—Black Butte.

10. *SEQUIOA*?, species.

Cones flattened, apparently long, linear-obtuse, marked at the surface by shields of scales, (apophyses,) the only organs preserved. These are separated from each other, not continuous nor imbricate, rhomboidal in outline, with acute sides, and rounded top, bearing in the middle a round mamilla, from which wrinkled lines are diverging to the borders. The specimen represents two crushed cones, of which nothing can be seen but what is described here.

HABITAT.—Middle Park, Dr. F. V. Hayden.

11. *ARUNDO REPERTA*, sp. nov.

Stem thick, articulated; surface striated, marked with round, obtuse knots, either placed on the articulations or here and there upon the stem, without normal distribution; ear of seeds crushed, representing lanceolate glumes, sharp-pointed and rounded at base, and ovate-lanceolate-acute seeds, truncate at the base, with the center elevated or convex, apparently covered with a coating of hairs. The glume is longer than the seeds, and nerved in the middle.

HABITAT.—Green River, west of the station, Dr. F. V. Hayden.

12. *ARUNDO OBTUSA*, sp. nov.

Though the specimen is not as well preserved as that of the former species, the characters of the organs which it represents are discernible, and indicate a marked specific difference. The striæ or primary veins of the small fragment of a branch are thick, more distinct, and evidently separated by four or five thinner secondary veins; the glumes and pallets are shorter, equally striate, without middle nerve, and the seed is much shorter, broader, obtuse at one end, and truncate at the other. The fragment which I consider a pallet is slightly emarginate or truncate at the point.

HABITAT.—Golden, South Table Mountain.

13. *PALMACITES GOLDIANUS*, sp. nov.

Species representing a large fragment of a flabellate leaf with five to nine rays on each side, of a flat, narrow, linear rachis. Rays averaging one and a half centimeters broad, marked by deep, narrow furrows, without costæ, joining the rachis in an acute angle of twenty degrees, united to it by their whole undiminished base, without decurring along it. Surface somewhat shining; substance thick; primary veins distinct at least in some places, where the epidermis is destroyed, two to two and a half millimeters distant, separated by ten secondary veinlets, thin, but often discernible to the naked eyes.

HABITAT.—Golden.

14. *SABAL COMMUNIS*, sp. nov.

Leaves of medium size, borne upon a nearly flat or merely convex petiole, its top passing at the upper side into a short acuminate rachis, while on the lower side it is cut horizontally or nearly truncate; rays not very numerous, the lowest in right angle to the rachis, not descending lower than its base, rapidly enlarging, carinately folded near the point of attachment to the rachis, becoming mostly flat or scarcely carinate upward; carinæ narrowly costate; primary veins broad, generally black when the epidermis is removed, one to two millimeters apart; intermediate veins thin and numerous, averaging twelve in the large intervals of two millimeters. This species is closely related to *Sabal andegaviensis*, Schp. of the Eocene of Angers, France.

HABITAT.—Golden, where it is common.

15. *MYRICA LUDWIGII*, Schp.

Leaves of middle size, subcoriaceous, oblong or linear-lanceolate, gradually tapering into a long entire acumen, distantly and deeply dentate along the borders; middle nerve thick; secondary veins subopposite, open, parallel, curving in passing to the borders, camptodrome, forking at the base of the teeth, the branches entering them, while the top of the veins is curved along the borders.

HABITAT.—Green River group, near mouth of White River, Prof. W. Denton.

16. *MYRICA INSIGNIS*, *sp. nov.*

Leaf membranaceous, large, narrowly-oval or oblong acuminate, pinnately-lobed; lobes short, entire, turned upward, triangular-acute; lateral veins open, slightly curving in passing to the point of the lobes; tertiary veins nearly as thick as the secondary ones, forking under the acute sinuses of the lobes, the branches ascending along the sides; areolation large, polygonal, formed by the anastomosis in the middle of the areas of nervilles at right angle to the veins. There are of this beautiful species two fragments of leaves, indicating the average size of ten centimeters long and four centimeters broad. The point, as in the former species, is entire, and still more rapidly and acutely acuminate; and the lobes, alternate, short, equal and similar, give to this species a beautiful appearance.

HABITAT.—Middle Park, *Dr. F. V. Hayden.*

17. *MYRICA* ? *LESSIGIANA*, *sp. nov.*

This species is represented by nearly the half of the leaf, enormous, at least if it belongs to this genus. Leaf linear, oblong in outline, deeply lobed; lobes opposite, ovate-lanceolate, obtusely pointed, at an open angle of divergence, entire, joined at a short distance of the thick middle nerve in obtuse sinuses; lateral veins thick, subopposite on an open angle of divergence, ascending to the point of the lobes, ramified from the middle upward in branches curving to and along the borders; tertiary veins, variable in thickness, relative position and direction, some forking under the sinuses, and passing up on both sides of it; others traversing the large intervals between the base of the secondary veins and the borders of the lobes, and following the borders in multiple festoons; areolation of the same character as in the former species, the large areolæ, however, being subdivided in very small meshes of the same character.

This magnificent leaf seems of a pellucid texture, though thick; at least, all the details of areolation and nervation are distinctly perceivable in black upon the chestnut-color of the leaf. Though the fragment does not represent one-half of the leaf, the terminal leaflet being destroyed, and the base also, still it is twenty-three centimeters long and eighteen centimeters broad, each lobe being nine to ten centimeters long from the middle nerve to the point, and seven and a half centimeters broad between the sinuses. It is doubtful if this leaf represents, as the former, a species of the section of the *Comptonia*. It resembles *Comptonia grandifolia*, Ung., which was till now considered as the giant representative of the section, but whose leaf is scarcely half as large as this. The nervation and areolation of this leaf are of the same character as that of *Myrica*, identical, indeed, to that of *M. Matheroniana* Sap., Et. II, 2, p. 93, T. V., Fig. 7, whose lobes are also of the same form. It is much larger, however, too large it seems for a *Myrica*. By the form of the leaf it is comparable to *Aralia multifida* Sas., Et. I, 1, T. XII, f. 1 and 1^a, and also but more distantly to *Cussonia polydrys* Ung., Flora von Euboea, p. 47, T. XVII, f. 1.

HABITAT.—Found in connection with a bed of lignite west of Denver, Colo., and kindly communicated by Mr. W. H. Lessig, who discovered it, and had the specimen framed in a bedding of plaster.

18. *BETULA VOGDESII*, *sp. nov.*

Leaves small, ovate, acutely-pointed, rounded, and narrowed to the petiole, minutely serrulate, penninerve, lateral veins distant, opposite at or

near the base, simple or rarely branching, passing up in an angle of divergence of thirty to thirty-five degrees, nearly straight to the borders, craspedodrome; details of areolation obsolete.

HABITAT.—Near Fort Fetterman, in connection with a profusion of remains of *Taxodium distichum*, *Lieutenant Vogdes*.

19. *CASTANEA INTERMEDIA*, *sp. nov.*

Leaves proportionally long and narrow, linear-lanceolate pointed, narrowed to the base; borders equally and sharply dentate; teeth acuminate, turned upward; areolation and nervation similar to that of *Castanea Vesca*. By its character it is intermediate between *Castanea Unger* of the Miocene and *C. vesca*.

HABITAT.—Middle Park, *Dr. F. V. Hayden.*

20. *CARPINUS GRANDIS*, Ung.

This species, so common in the Miocene of Europe, is represented in our flora by a number of leaves identical in all the characters.

HABITAT.—Near Florissant, South Park, *Dr. F. V. Hayden.*

21. *QUERCUS HAIDINGERI*, Ett.

Leaf ovate-lanceolate, narrowed to the base (point broken); borders obtusely crenato-serrate; lateral veins numerous, close, on an angle of divergence of forty to forty-five degrees, rarely branching, camptodrome and craspedodrome. The leaf appears to be tapering to a point. It is upon coarse sandstone, and the details of areolation are totally obliterated. By its form, the divisions of the borders, and the nervation, it agrees with the characters of the species, except that in this leaf the middle nerve is not thick, as described by Heer.

HABITAT.—Green River, *Dr. F. V. Hayden.*

22. *PLANERA UNGERI*, Ett.

Leaves short-petioled, ovate, acuminate, narrowed to the base, simply, coarsely serrate from the middle upward; secondary veins nine pairs, passing up to the point of the teeth in an acute angle of divergence. This form, though represented by one leaf only, is in entire concordance of characters with those of this species widely distributed in the Miocene of Europe.

HABITAT.—South Park, *Capt. Ed. Berthoud.*

23. *FICUS OVALIS*, *sp. nov.*

The only leaf representing this species is coriaceous, oval, entire, narrowing in a curve to a long thick or flat broad petiole, grooved in the middle penninerv; lateral vein alternate, camptodrome, curving along the borders in festoons; tertiary veins short; areolation obsolete. The upper part of the leaf is broken.

HABITAT.—Pleasant Park, Plum Creek, *Dr. F. V. Hayden.*

24. *FICUS PSEUDO-POPULUS*, *sp. nov.*

Leaves oval-pointed, narrowed to the petiole, entire, three-nerved from the top of the petiole; lateral veins at an acute angle of divergence, like the secondary veins, two or three pairs, the lower of which is at a great distance from the primary ones, camptodrome; nervilles distinct, in right angle to the midrib, crossed by oblique branchlets, forming a large equilateral or polygonal areolation. A remarkable species,

resembling a *Cinnamomum* by the nervation of its leaves and a *Zizyphus* by the form.

HABITAT.—Evanston, Dr. F. V. Hayden.

25. *FICUS WYOMINGIANA*, *sp. nov.*

May be a variety of the former, resembling it closely by the form of the entire, long-petioled leaf. The difference is marked, however, by the total absence of secondary veins; the middle nerve being joined to the lateral ones by strong nervilles in right angle.

HABITAT.—West of Green River station, Dr. F. V. Hayden.

26. *DIOSPYROS? FICOIDEA*, *sp. nov.*

Leaf ovate, narrowed to a point (broken), rounded to the petiole, thickish, entire, pinnately-nerved; midrib thick, deeply marked, as also the secondary veins, parallel, at an acute angle of divergence, all doubly camptodrome; fibrillæ thick, nearly in right angle to the veins, divided in the middle; areolation square or polygonal; surface rough. The generic relation of these leaves is not satisfactorily fixed.

HABITAT.—Black Butte.

27. *VIBURNUM PLATANOIDES*, *sp. nov.*

This species essentially differs from *Viburnum marginatum* by the less numerous, more open, lateral veins, whose branches are more curved in passing up to the borders, and especially by the enlarged truncate or subtruncate base of the leaves. The direction of the veins along the lower branches of the lateral veins is the same, and the borders are dentate in the same manner, though not black-margined as in *V. marginatum*.

HABITAT.—Black Butte, mixed with Saurian bones, and as abundant in that bed as is its congener, in the shale above the main coal of the same locality.

28. *CISSUS PAROTTIÆFOLIA*, *sp. nov.*

Leaves ovate-subcordate or narrowed to the base, gradually and obtusely pointed, undulato-crenate, three-nerved from the top of the petiole or from a little above the border-base; lower secondary veins at a distance from the primary ones, which are much divided; all the branches, like the secondary veins, craspedodrome; nervilles strong, in right angle to the veins; areolation small, square, by subdivision of veinlets.

The species is represented by a few leaves, one of them, fragmentary, has a cordate, unequal base, and may belong to a different species.

HABITAT.—Green River, west of the station, Dr. F. V. Hayden.

29. *RHAMNUS ROSSMÄSSLERI?*, Heer.

Leaves oblong-obovate, obtusely pointed, entire, narrowed to the base, penninerve; secondary veins close, parallel, passing to the borders nearly straight and curving along them in festoons. These leaves are small; one only is preserved entire; their specific relation is not fixed.

HABITAT.—Black Butte.

30. *PHASEOLITES JÜGLANDINUS?*, Heer.

Leaflets of an apparently compound leaf, oval-oblong, obtusely pointed, rounded to a short petiole, entire, subcoriaceous, penninerve; lateral veins parallel, distinctly camptodrome, and following the borders in festoons; ultimate areolation small, irregularly quadrate.

The species may be different from the European one bearing this name, but it appears to differ only by more open secondary veins.

HABITAT.—Green River group, near mouth of White River, Prof. Wm. Denton.

31. *LEGUMINOSITES ALTERNANS*, *sp. nov.*

Leaflet lanceolate, narrowed to the sessile base (point broken), apparently tapering and acute; borders entire; secondary veins close, numerous, fifteen pairs in a space of two and a half centimeters, with intermediate shorter tertiary veins anastomosing by crossing veinlets; areolation obsolete. This leaf is comparable to a *Dalbergia* or a *Podogonium* by its nervation; its form, especially the narrowed base, is comparable to *Cassia*.

HABITAT.—Near mouth of White River, Prof. W. Denton.

32. *SAPINDUS DENTONI*, *sp. nov.*

Leaves lanceolate, gradually narrowed to a long acumen, unequilateral and rounded at base to a short petiole, entire or slightly undulate, thick; secondary veins close, parallel, diverging forty to fifty degrees, thick, straight to the borders, where they abruptly curve, and which they closely follow.

Species allied to *Sapindus falcifolius*, Heer, but remarkably distinct from this and other congeners by the thick, close, lateral veins straight to the borders, where they curve so abruptly that they appear at first sight as craspedodrome. The areolation is of the same character as that of *S. falcifolius*.

HABITAT.—Green River group, near mouth of White River, Prof. W. Denton.

33. *LOMATIA MICROPHYLLA*, *sp. nov.*

Leaves very small, thick, coriaceous, linear-lanceolate, gradually narrowed to a point, and in the same degree to the base; secondary veins simple, thin, in an open angle of divergence, connected to a marginal vein. We have two leaves of this fine species. It is comparable to *Lomatia firma*, Heer, of the Baltic flora, but very small and thick; the surface mostly covered by a coating of coaly matter.

HABITAT.—Same locality as the former, Prof. W. Denton.

A large number of fruits and seeds, considered under the name of *Palmacites*, *Carpolites*, etc., have been figured for the Lignitic Flora. As the characters of these organs cannot be represented by mere description, they are not mentioned in this short synopsis.